Office of Technology Assessment

Congressional Board of the 100th Congress

MORRIS K. UDALL, *Arizona, Chairman*

TED STEVENS, *Alaska, Vice Chairman*

Senate

ORRIN G. HATCH
Utah

CHARLES E. GRASSLEY
Iowa

EDWARD M. KENNEDY
Massachusetts

ERNEST F. HOLLINGS
South Carolina

CLAIBORNE PELL
Rhode Island

House

GEORGE E. BROWN, JR.
California

JOHN D. DINGELL
Michigan

CLARENCE E. MILLER
Ohio

DON SUNDQUIST
Tennessee

AMO HOUGHTON
New York

JOHN H. GIBBONS
(Nonvoting)

Advisory Council

WILLIAM J. PERRY, *Chairman*
H&Q Technology Partners

DAVID S. POTTER, *Vice Chairman*
General Motors Corp. (Ret.)

EARL BEISTLINE
Consultant

CHARLES A. BOWSHER
General Accounting Office

S. DAVID FREEMAN
Lower Colorado River Authority

MICHEL T. HALBOUTY
Michel T. Halbouty Energy Co.

NEIL E. HARL
Iowa State University

JAMES C. HUNT
University of Tennessee

JOSHUA LEDERBERG
Rockefeller University

CHASE N. PETERSON
University of Utah

SALLY RIDE
Stanford University

JOSEPH E. ROSS
Congressional Research Service

Director

JOHN H. GIBBONS

The Technology Assessment Board approves the release of this report. The views expressed in this report are not necessarily those of the Board, OTA Advisory Council, or individual members thereof.

TECHNOLOGY AND THE AMERICAN ECONOMIC TRANSITION

CHOICES FOR THE FUTURE

SUMMARY

CONGRESS OF THE UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT

WASHINGTON, DC 20510-8025

J952-43

Contents

	Page
Introduction	**3**
Guide to the Analysis	5
Analysis by Networks	5
Policy Consequences	12
The Structure of the Report	14
Summary	**15**
The New Rules	15
New Technology	15
New Challenges From Abroad	18
New Resource Constraints	19
New Values and Tastes	19
Changes in Public and Private Regulations and Incentives	20
Choices Created by the New Rules	21
Economy-Wide Structural Change	21
Structural Change in the Eight Major Amenity Networks of the American Economy	40
Food	40
Health	41
Housing	43
Transportation	45
Clothing and Personal Care	46
Education	47
Personal Business and Communication	49
Recreation and Leisure	50
Pulling the Pieces Together	51

Foreword

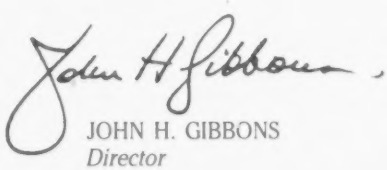
In many studies during the past decade and a half, the Office of Technology Assessment has analyzed hundreds of changes in American life that have been brought about by new technologies. In this study, for the first time, OTA steps back from the detailed analyses of individual industries and sectors to take a broad look at the combined impact of new technologies on American society. From this perspective it is possible to describe the opportunities and risks for the nation as a whole that are not apparent in studies targeted on topics that are more narrowly defined. The report highlights strategic choices available to Americans as we negotiate a period of major transformation. The choices we make will have profound consequences for the quality of work and the amenities available to Americans and for America's role of leadership in the free world.

Eight committees of Congress asked the Office of Technology Assessment to assess the new environment in which America's economy now operates as a result of new technologies, a global market, and related changes in consumer attitudes and behavior. OTA was asked to identify areas where existing policy might block attractive avenues of growth and where new policies could facilitate growth. The requesting committees represent a wide spectrum of congressional interest. They include the Senate Committee on Commerce, Science and Transportation; the Committee on the Budget; the House Committee on Energy and Commerce; the Committee on Post Office and Civil Service; the Committee on the Judiciary; the Committee on Public Works and Transportation; the Committee on Education and Labor; and the Committee on Science Space and Technology.

The analysis begins and ends by focusing on people in their role as consumers and as employees. It uses conventional economic accounting procedures to document economic growth, but also employs more qualitative standards for measuring progress in eight basic categories of demand or amenity: food, housing, transportation, health, clothing & personal care, education, personal communication & business, and recreation & leisure. It also uses standard methods for measuring gains in compensation paid to workers, but introduces other ways of evaluating job quality such as opportunities for learning and career advancement, the extent to which work and family responsibilities can be combined, and whether a person can take pride in his or her work.

The first chapter serves as an introduction to the themes developed in the document and a summary and guide to the entire report. Readers will find this a useful way to identify sections on consumption, business structure, trade, employment, education, or other topics that may be of special interest to them. We feel that the major accomplishment of this document, however, lies in the way it helps develop a perspective on these issues—showing how the networks of production and consumption are interconnected, how international and domestic economies are connected, and how changes in one area spread through the nation's entire economic and social fabric.

The study was undertaken with the help of many individuals and institutions around the United States. We owe a particular debt to individuals in the U.S. Department of Commerce and the U.S. Bureau of Labor Statistics who not only provided data and reviewed OTA's work but gave us crucial insights and guidance about their complex resources. Responsibility for the contents of this document, of course, rests with OTA.



JOHN H. GIBBONS
Director

Technology and the American Economic Transition Advisory Panel

David Saxon, *Chairman*
Chairman of the Corporation, Massachussetts Institute of Technology
Cambridge, MA

Claude Ballard
Partner
Goldman Sachs
New York, NY

William Baumol
Department of Economics
Princeton University
Princeton, NJ

Harvey Brooks
John F. Kennedy School of Government
Harvard University
Cambridge, MA

Richard Crowder
Senior Vice-President
Pillsbury Co.
Minneapolis, MN

Thomas G. Denomme
Vice-President
Chrysler Corp.
Highland Park, MI

Judith Gregory
Department of Communications
University of California at San Diego
La Jolla, CA

Henry A. Lichstein
Vice President
Citibank
New York, NY

Mary Jo Manning, Esq.
Partner
Wilkes, Artis, Hedrick, & Lane
Washington, DC

Ray Marshall
L.B.J. School of Public Affairs
University of Texas
Austin, TX

John J. McNamara
McCann Erickson
New York, NY

Kathleen O'Reilly, Esq.
Executive Director
Citizens Utility Board
Madison, WI

Charles F. Sabel
Department of Science, Technology and Society
Massachusetts Institute of Technology
Cambridge, MA

George M. Scalise
Senior Vice President
Advanced Micro Devices
Sunnyvale, CA

Al Sobey
Director of Energy and Advanced Product Economies
General Motors Corp.
Detroit, MI

Barbara Starfield
School of Hygiene and Public Health
John Hopkins University
Baltimore, MD

Arthur G. Wirth
Department of Education
Washington University
St. Louis, MO

Howard Young
Livonia, MI

NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

OTA Project Staff: Technology and the American Economic Transition

Lionel S. Johns, *Assistant Director,*
Energy, Materials, and International Security Division

Henry C. Kelly, *Project Director*

Andrew W. Wyckoff

Daniel J. Chenok

Joy Dunkerley

Review & Counsel

Peter Blair

Audrey Buyrn

Walter Parham

Peter Sharfman

Contributors

Food: **Mark Bello**, Charles Abdalla, John Connor, Kenneth Cook, Jack Giacin, Roger Griffin, Steve Hiemstra, Eric Hyman, Chester Mackson, Rosanna Morrison, Stanley Johnson, Bruce Harte, Robert Evenson, Carl Pray, Jonathan Putnam, Theron Downes, Ronald Cotterrill.

Health: **Zeda Rosenberg**, Nicholas Ashford, Tony Bale, Howard Berliner, Robert Curtis, Eli Ginzberg, Peter Goldschmidt, Dale Hattis, Irene Jillson-Boostrom, Louanne Kennedy, Andrew Martin, Mariam Ostow, Curtis Priest, Herbert Semmel, Alvin Strelnick

Housing: **David Dowall, Robert Gold**, Vincent Brannigan, Edward Starostovic, Steven Winter, Alton Bradford,* Don Carlson,* David Claridge,* Michael Clevenger,* Albert Dietz,* Eric Dluhosch,* John Eberhard,* James Gross,* Harry Mileaf,* John Millhone,* Piero Patri,* Richard Reisman,* Richard Tucker,* Charles Thornton,* Wendel Wendel,* Raymond Whitten*

Transportation: **Elizabeth Deakin, William Garrison**, Robert Cervero.

Education: **Francis Fisher**, Alfred Bork,* Lewis Branscomb,* John Seely Brown,* Andrew Calkins,* Margaret Cox,* Richard Cyret,* Christopher Dede,* Dorothy Deringer,* David Docterman, J. Dexter Fletcher,* William Gattis,* John Goodlad,* John Kemeny,* Daniel Levin,* J.C.R. Licklider,* Milbrey McLaughlin,* Arthur Melmed,* Andrew Molnar,* Billy Reagan,* Theodore Sizer,* Thomas Snyder,* Patricia Sturdivant*

Communications: **Robert Bolter, Donald Dunn**, Jamie Grodsky, Jim McConnaughey

Recreation and Leisure: **Steven Ackerman**, Anindya Bose, Arlene Fleming, Margaret Fischer, Haines Gaffner, Robert Howard, Steve Sieck, Robert November, Peter Verhoven

Textiles and Apparel: **Ruth Ruttenberg,** Gordan Berkstresser, N.C. Williamson.

International Trade Issues: **Steven Haggard**, Michael Aho,* Steven Cohen,* Peter Kenen,* Raymond Vernon,* William Wallace,* John Zysman*

Manufacturing Issues: Steven Cohen, Barbara Baran, Bruce Guile, Carol Parsons, Robert Scott, Jean Ross.

Analytics: Frank Bean, William Booth, Mary Feng, Jan Graf, David Gillman, Gail McGrew, Lori Renner

Time Use: **John Robinson**, Jeffrey Holland

Editorial & Inspirational: Robin Clarke, Ann Kelly, Robert Niblock, Emilia Govan

Administrative Staff: Phyllis Brumfield, Lillian Chapman, Linda Long

OTA Publishing Staff: Kathie Boss, James Agee, John Bergling, James Brown, Debra Datcher, Cheryl Davis, **Dorinda Edmondson, Chip Moore**

*Prepared papers for workshops held in connection with this project.

List of Related OTA Reports

***Technology and the American Economic Transition* Supporting Reports**

- Special Report
  - —*Technology, Trade, and the U.S. Residential Construction Industry*
    OTA-TET-315, September 1986, NTIS order #PB 87-117 594/AS
  - —*The U.S. Textile and Apparel Industry: A Revolution in Progress*
    OTA-TET-332, April 1987, NTIS order #PB 87-196 762/XAB
- Technical Memorandum
  - —*A Review of U.S. Competitiveness in Agricultural Trade*
    OTA-TM-TET-29, October 1986, GPO stock #052-003-01054-2,
    NTIS order #PB 87-140 760/AS
- Panel Proceedings
  - —*Technology and the Future of the U.S. Construction Industry*
    AIA Press, 1986, NTIS order #PB 86-209 442/AS

Other OTA Reports

- *New Electric Power Technologies*
  OTA-E-246, July 1985, GPO stock #052-003-01005-4,
  NTIS order #PB 86-121 746/AS
- *International Competition in Services*
  OTA-ITE-328, July 1987, GPO stock #052-003-01067-4,
  NTIS order #PB 87-212 403/AS
- *Trade in Services: Exports and Foreign Revenues*
  OTA-ITE-316, September 1986, GPO Stock #052-003-01049-6,
  NTIS order #PB 87-118 204/AS
- *Technology and Structural Unemployment*
  OTA-ITE-250, February 1986, GPO stock #052-003-01017-8,
  NTIS order #PB 86-206 174/AS
- *Technology, Public Policy, and the Changing Structure of American Agriculture*
  OTA-F-285, March 1986, GPO stock #052-003-01018-6,
  NTIS order #PB 86-184 637/AS
- *Preventing Illness and Injury in the Workplace*
  OTA-H-256, April 1985, NTIS order #PB 86-115 334/AS
- *Life Sustaining Technologies and the Elderly*
  OTA-BA-306, July 1987, GPO stock #052-003-01074-7
  NTIS order #PB 87-222 527/AS
- *The Electronic Supervisor: New Technology, New Tensions*
  OTA-CIT-333, September 1987, GPO stock #052-003-01082-8
  NTIS order # PB 88-156 351/AS
- *Automation of America's Offices*
  OTA-CIT-287, December 1985, NTIS order #PB 86-185 055/AS
- *Computerized Manufacturing Automation*
  OTA-CIT-235, April 1984, GPO stock #052-003-00949-8,
  NTIS order #PB 84-196 500/AS
- *Technology, Innovation, and Regional Economic Development*
  OTA-STI-238, July 1984, GPO stock #052-003-00959-5,
  NTIS order #PB 85-150 894/AS

NOTE: Reports are available through the U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402-9325, (202) 783-3238; and the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22162-0001, (703) 487-4650.

Summary

INTRODUCTION

During the next two decades, new technologies, rapid increases in foreign trade, and the tastes and values of a new generation of Americans are likely to reshape virtually every product, every service, and every job in the United States. These forces will shake the foundations of the most secure American businesses. Few features of the change seem inevitable. The Nation's future has probably never been less constrained by the cost of natural resources or the limits of human strength, dexterity, or memory. Much less depends on physical limits to what *can* be done and much more on what Americans *choose* to do, acting privately as consumers, investors, and employees and publicly as voters.

The choices will affect the options available to consumers, the rate and nature of growth in different business sectors, the geography of growth, and the role played by large and small enterprises. They will affect America's position in the world economy and the number and quality of jobs the American economy produces.

This document is designed to describe the nature and consequences of some of these choices.

Given the importance of choice, it would be foolish to make confident predictions about the future of America's economy. It is possible, however, to outline a set of exciting possibilities. They include opportunities to: extend life and reduce sickness and disability; create more choices in recreation and entertainment; expand access to information about products and services; have products and services more precisely tailored to personal needs and tastes; and make learning more productive and accessible.

There are also opportunities for making work more rewarding—in all senses of that term. Technology can replace many of the most tedious, dangerous, and dehumanizing tasks while creating jobs that require more intellectual and social skills. Machines are likely to plant seeds, weave cloth, fabricate metal parts, handle routine paperwork, enter data, and perform a vast number of other repetitive tasks more efficiently and more productively than people. By default, the majority of jobs created in the economy could be those requiring human, and not machine-like skills: designing; tailoring products and services to unique customer needs; teaching; caring; entertaining; promoting; and persuading. Ironically, one result of sophisticated technology may be a work force whose primary task is dealing with people—as customers or as colleagues.

With each opportunity for progress, of course, there are opportunities for serious missteps. Even change that clearly leads to overall economic growth can have very uneven effects. Change can lead to wrenching dislocation and pain for workers with obsolete skills, for management unable to recognize opportunity, and for communities where traditional businesses have failed. Change can create an America in graceless decline—its living standards falling behind those of other world powers. This could mean an America less able to ensure the operation of free international markets and less able to ensure the security of the free world. Change can weaken the bargaining position of some groups while strengthening that of others. Change can result in a growing gap between those fortunate enough to have the talents, education, and connections needed to seize emerging opportunities and those forced into narrowly defined, heavily monitored, temporary positions. This latter group could be forced to bear most of the costs of uncertainty.

A central issue is at the core of the choices: will change increase or decrease the power of individuals? Specifically:

- Will it become easier to purchase products tailored to specific interests, or will choices be constrained as national production systems substitute standard products for specialized products reflecting individual interests or local tastes?
- Will businesses change and grow under the assumption that workers will be well educated and intellectually flexible, or will they plan with the assumption that workers will be ignorant, untrainable, and unreliable? Another way of asking this question is whether people will be able to find a variety of attractive opportunities for work, or whether only a credentialed elite will enjoy such opportunities.

From another perspective, the issue is whether the flexibility and dynamism essential to progress in the emerging economy will come at the expense of individuals, or whether individuals themselves will become more flexible because of continuous opportunity for learning and growth. In the past it seemed necessary to make a Faustian compact with technology: efficiency could be improved only by sacrificing individuality. Efficiency demanded mass production of uniform products, and a reasonable income often required acceptance of a constraining and narrowly defined occupation. It is at least possible that emerging technology will make it possible to avoid such a choice.

Can America operate a dynamic and growing economy and navigate a transition to a new, more flexible, economic structure without falling into any of many potential traps? Specifically, can the U.S. Government create a set of marketplace rules that bring private and public goals into greater harmony without stifling the innovation and entrepreneurship needed to reach these goals? Can both workers and investors have incentives to undertake major changes in production systems? Can a major transformation be managed so that unavoidable trauma will not all be borne by a single group?

The following pages argue that the answer to all these questions is yes—but only given an unflinching reexamination of some of the most cherished notions about the way businesses are managed internally, and about the way networks of enterprises work together. In the end, the choices governing the direction taken by the economy will be made by individual Americans acting as consumers with diverse interests, employees interested in rewarding work, and investors in search of profits. The rules under which these choices will be made are the issue. The collection of rules, regulations, and incentives adopted over the past several decades for perfectly good reasons may send misleading signals today.

Programs designed to create growth in new directions require an ability to think in clear, practical ways about the way skills and investment are connected to the provision of good health, recreation, and other amenities measured in human terms. The baffling complexity makes it easy to be misled about where real opportunities for progress lie. Indeed, it can make it difficult to believe in the possibility of system-wide progress.

The analysis that follows provides a practical set of tools for evaluating the performance of an economy that operates increasingly as a set of complex networks, which add value in many different ways and in many different locations before a product or service finds its way to a household. It also develops a set of concrete hypotheses about the way economic networks *could* operate in the future. The document does not attempt to forecast the future. Forecasting implies that choice plays a minor role. Instead, the analysis attempts to provide the clearest possible description of the available choices and their implications.

The changes discussed in this volume appear to make prescriptive government planning less desirable. This does not necessarily mean that the responsibilities of government are reduced. Government maintains a central role because it creates many of the rules under which private choices are made. It may also have a growing responsibility for ensuring that Americans have adequate access to education throughout their lives, for ensuring a continuous flow of invention and innovation, and for protecting individuals from the dangers and risks of rapid economic change.

Eight congressional committees asked the Office of Technology Assessment to take a broad look at the opportunities and risks created by the new environment in which America's economy now operates, in order to identify areas where existing policy might block attractive avenues of growth and where new policy could improve incentives.

Real economic growth requires both a belief that progress is possible and a vision of progress that is broadly shared. Government cannot create such vision, but it can provide a place where such visions emerge. The genius that has driven U.S. prosperity throughout its history has been an ability to combine collective vision with diversity and individualism—to unite grand ideals with hard pragmatism. As the United States enters the 21st century, this genius will be put to its severest test.

GUIDE TO THE ANALYSIS

Analysis by Networks

Given the broad goals of this analysis, it is necessary to take a very basic look at the way the economy operates as a whole. The vocabulary and the accounting techniques used to describe the economy, however, can limit our ability to imagine fundamental change. They embody many implicit assumptions about values and the way an economy operates. There is no obvious way, for example, to know whether a shift to an economy heavily based on "services" is either a fate to be embraced or avoided. In many manufacturing industries most employees never touch production equipment; more than half the cost of producing a computer, for example, typically results from software development. Should computer manufacturing now be considered a service? Many "service" workers are now involved in facilitating the design and delivery of manufactured products tailored to specific needs, or in facilitating the formation of production networks needed for timely delivery of new products. Should growth in these enterprises be read as the decline of manufacturing?

In an effort to avoid the traps of these and other abstractions, this analysis concentrates on some basic concepts:

- However sophisticated the economy may become in the future, its final products must always be the production of what will be called "amenity" throughout this volume. Amenity is intended to mean anything that contributes to the comfort, convenience, or happiness of an individual or household. While amenity is measured differently by every person, the "amenity categories" remain essentially unchanged in basic areas like health, food, housing, entertainment, and security. Progress in the economy must ultimately be measured by the extent to which the quality of these amenities has been improved, and by the extent to which these improvements are shared by the least fortunate groups in America.

  There are no easy ways to monitor gains in amenity. Growth in average income per person provides only a limited view of changes taking place. Averages, for example, can mask increasing differences between wealthy and poor households. Growth in spending on burglar alarms is obviously not a good measure of security. Increased medical spending is not a good measure of national health.
- However sophisticated the economy becomes, the networks providing amenity directly or indirectly generate all the employment created by the economy. Barring the development of a pill that increases native intelligence or removes the need for sleep, the basic resources of time, talent, and enthusiasm available in the work force will not be altered by any economic transformation.

  Change can, however, affect the mix of skills demanded throughout the economy, and the links connecting income to skill. It can alter the quality of education offered by the work force, and the capacity of workers to learn and adapt to shifting circumstances. It can alter the quality of jobs, the texture of a working day, and the extent to which a person can take pride and pleasure in the work. The quality of working life is itself an important amenity.

Most of the following analysis is devoted to an examination of the way amenity and jobs are connected in today's economy and the way these connections may change during the next two decades. Understanding these connections, of course, requires a clear understanding of the way a modern economy operates. The goal is to enter these intricacies without losing track of the fact that the analysis must begin and end with people.

Paradoxically, even in an economy increasingly based on information flows the simplest questions seem more difficult to address. The information available can be overwhelming rather than helpful. The analytical strategy proposed here attempts to close the gap between speculation based on anecdotes and quantitative analysis based on national economic statistics. It uses statistical analysis wherever possible, but combines these results with the insights of experts in areas where statistics are not available or

are difficult to interpret. Above all, the method is designed to be flexible enough to describe opportunities for basic structural change.

A Parable

Before describing the methods of this study in more detail, it is useful to look at an example of a contemporary production network. What could be more basic than a frozen pizza? A man cooking a frozen pizza in a microwave oven cares about what the pizza costs, how it tastes, how its preparation fits into his increasingly harried lifestyle, and maybe a bit about whether it is good for his diet or health. In effect, he cares about the net productivity of the network of activities (including the time he invested in cooking and learning about health) that brought the pizza to his palate. He probably couldn't care less whether it was the product of a manufacturing economy, a service economy, an information economy, or an international economy. But consider a likely chain of events that culminated in the pizza. Knowledge about health effects of food came from a TV talk show and information about a sale on pizza from a newspaper ad. Wheat for the pizza crust was grown in Kansas using sophisticated seeds and pesticides. The pizza was assembled automatically and wrapped in materials that are themselves the product of considerable research. The pizza was probably purchased at a grocery store where a clerk passed it over a laser scanner, which entered data into a computer and communication system designed to adjust inventories, restock shelves, and reorder products. This system in turn made it possible to operate an efficiently dispatched transportation system, placing a premium on timely and safe delivery rather than on low bulk hauling charges. The checkout data were probably also used to analyze consumer response to the previous day's advertisement and to ensure that the store was closely following trends in neighborhood tastes.

This pizza parable is important because food remains a major part of the U.S. economy. The parable is even more important, however, because it contains many of the themes now reshaping the American economy.

It is difficult to argue that the United States has moved beyond an agricultural economy when one person in seven still works directly or indirectly to bring food to American tables. Demand for food continues, but the jobs involved in supplying it are very different from those of our grandparents. In 1984, only 4 of every 100 jobs in food production were on farms. The number of lawyers, bankers, scientists, and accountants needed to supply food in 1984 was about equal to the number of farmers. More than half the jobs supplied by the food network were for sales workers (20 percent), precision craftsmen (12 percent), managers (11 percent), and data entry clerks (10 percent).

Technology plays a crucial role at each step of the network of business activity just described. Foreign products enter at many points: the pizza may contain tomatoes from Mexico, may be prepared by food handling equipment from West Germany, and may be sold using checkout equipment from Japan. While the rules governing the network are primarily those of private markets, the role of government is pervasive. Government regulations control the safety and labeling of products. Public funds supply the highways crucial to food delivery. Many farmers spend hours finding ways to benefit from government farm programs.

Basic Tools for Representing Networks

The analysis presented in this study begins by dividing the entire output of the U.S. economy into 10 components, identified by the amenity they provide:

- Food,
- Housing,
- Health,
- Transportation,
- Clothing and Personal Care,
- Education,
- Personal Business and Communication,
- Recreation and Leisure,
- Defense, and
- government activities not elsewhere classified.

Only the first eight amenity groups are analyzed in detail in the material that follows. Changes in demand and in production efficiencies, have reduced the fraction of America's income spent on each amenity. During the past three decades, the fraction of spending used to purchase Food has declined while the fraction spent on Health, Education, Per-

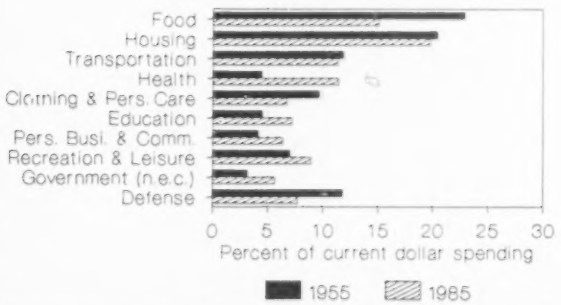
sonal Business and Communication, and Recreation and Leisure has increased (see figure 1-1).

The amenity ultimately enjoyed by each individual or household is achieved through a complex series of steps, each of which adds value of some kind. The value may be contributed by investments of household time, or may be added by a business that contributes to a purchased product or service. The final value of a purchased frozen pizza, for example, includes value contributed by farmers, packers, truckers, wholesalers, grocery stores, and the collection of legal, financial, insurance, and other firms that facilitate transactions needed by the complex network of activities.

The methods this analysis uses to keep track of the flow of value in economy are summarized in figure 1-2, which illustrates four basic steps in the network connecting people as consumers to people as employees and investors:

1. *Consumption Recipes.* These "recipes" describe the way households achieve each amenity by combining time invested by household members, purchased goods, purchased services, and goods and services purchased by the government. (The mix of private and public spending in 1985 is summarized in figure 1-3.) A recipe for the amenity called "Health" includes personal time and money spent promoting good health (e.g., through diet and exercise), preventing disease and accidents (e.g., vaccinations, wearing seat belts, or taking drugs to control high blood pressure), and public investments in environmental quality, as well as clinical care purchased from doctors, hospitals, and a variety of other institutions. The formal and informal regulations guiding these decisions can be extremely complex. This document analyzes consumption recipes in each of eight sectors in two ways: first, by examining trends (based on

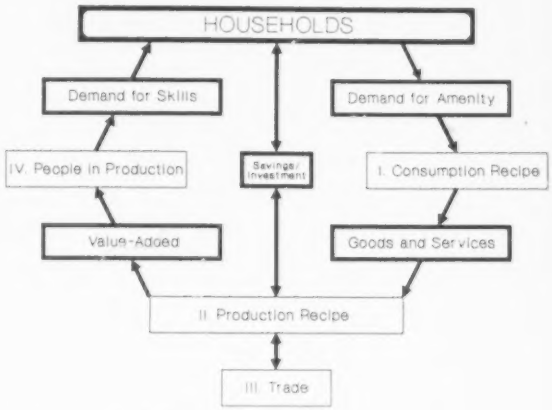
Figure 1-1.-How America Spent Its Money (percent of all personal and government spending in current dollars)



How To Read This Figure: Fifteen percent of all household and government spending in 1985 went to purchase food, down from 23 percent in 1955. The spending totals shown do not include the purchase of new housing since this is considered to be a form of savings.

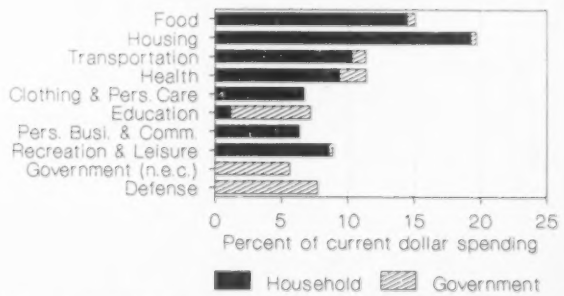
SOURCE: Based on U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4, 3.15, 3.16 (see figures 2-1a to 2-1c of ch. 2 for detail).

Figure 1-2.-Structure of the Analysis



SOURCE: Office of Technology Assessment.

Figure 1-3.-Private and Public Spending on Amenities in 1985



How To Read This Figure: Of all household and government spending in 1985, 14.5 percent was spent by households to purchase food and 0.5 percent by government to purchase food or support food production.

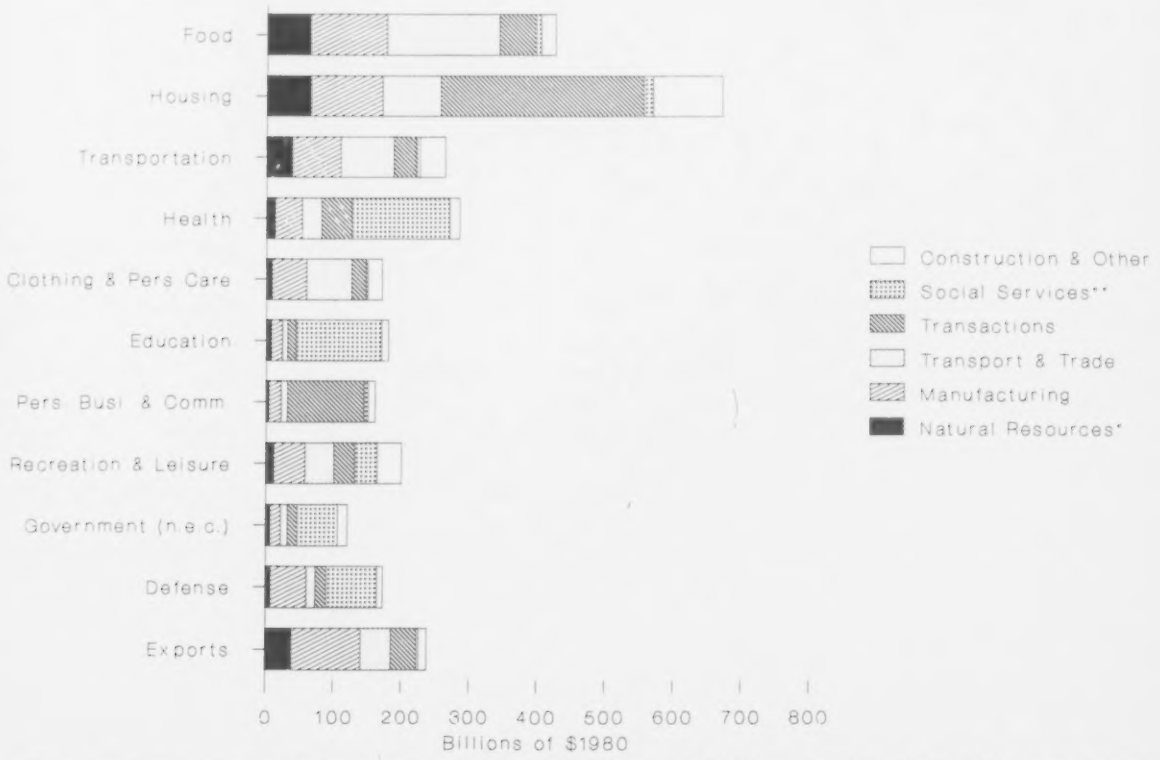
SOURCE: Office of Technology Assessment (see table 2-2 of ch. 2).

a mathematical analysis of the way spending correlates with price, income, household structure, and other factors); and second, by examining the possibility that entirely new directions may be taken because of unexpected new products, changes in consumer education, changes in tastes, or changes in formal regulations.

2. *Production Recipes.* These "recipes" represent the mix of ingredients needed by producers to supply household and government buyers with products and services. Each business produces output by combining material and services purchased from other businesses with value that is added by the business itself. This value takes the form of labor performed by the business' employees and the returns paid to investors for use of capital. Tracing the value that ultimately appears in the price of a consumer product requires an understanding of the way value is added by a complicated network of businesses that supply each other. If the purchasing "recipe" of each business is known, it is possible to estimate the wages and profits generated in each sector in the process of satisfying the eight major classes of consumption. The result of such an analysis for 1984 is shown in figure 1-4.[1]

[1]Information in this and other tables displayed in this chapter must be treated with some caution. They are based on a large number of assumptions discussed in greater detail in later chapters.

Figure 1-4.-Where Is Value Added? (value-added by production sector in 1984)



How To Read This Figure: In 1984, the U.S. gross national product (GNP) was $2,890 billion (1980 dollars). Of this total, approximately $430 billion went to produce food for U.S. household and government purchasers. Of this $430 billion, $64 billion ended up as value-added (primarily employee compensation and profits) earned in Natural Resource businesses (a category that includes farming, fisheries, energy, and mining businesses). If the bars for each amenity group were placed end to end, the sum would equal the total U.S. GNP.

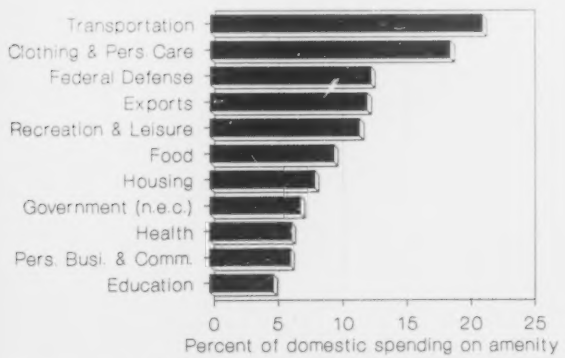
*Farming, Mining, and Energy.
**Education, Health, and other Government.

SOURCE: Office of Technology Assessment (see table 4-6a of ch. 4).

3. *International Connections.* Imported products have insinuated themselves into the domestic production recipes in complex ways (see figure 1-5), while nearly 10 percent of the U.S. gross national product (GNP) is sold abroad as exports. Trade of this magnitude obviously changes some of the basic rules under which domestic production networks operate. Different parts of the economy vary greatly in the way they are affected by trade. One dollar in five spent for Transportation ends up abroad, either directly (as in purchases of foreign cars or fuel) or indirectly (as in expenditures for steel used to produce automobile parts). About 12 percent of the price of products exported by U.S. firms results from imported products. Patterns of involvement can change rapidly. Housing, for example, was comparatively isolated from world trade in 1984 but there may soon be rapid growth in imported housing components.

Figure 1-6 provides a rough estimate of the way trade affects domestic employment. Estimates of the displacement effects of imports are highly artificial, since they depend on assumptions about how U.S. firms would produce substitutes for imports. Gains and losses exceed 25 percent in some sectors.

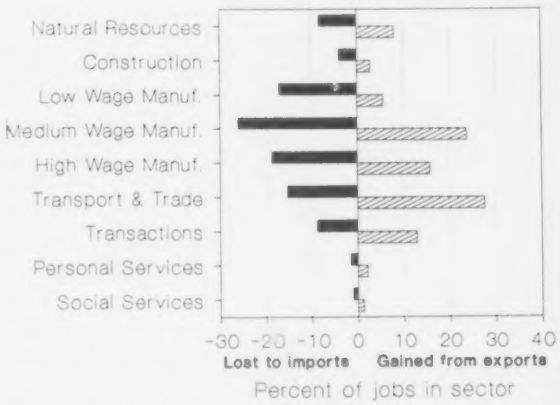
Figure 1-5.-Imports Used Directly or Indirectly To Produce Amenity in 1984



How To Read This Figure: 21.2 percent of the money spent by U.S. households and government for transportation in 1984 was spent abroad to purchase petroleum, automobiles, automobile components, and other products and services.

SOURCE: Office of Technology Assessment (see table 7-11 of ch. 7).

Figure 1-6.-Employment and Trade in 1984 (jobs gained and lost from trade)



How To Read This Figure: If there had been no exports of any kind in 1984, there would have been approximately 8% fewer jobs in Natural Resource businesses in 1984. If there had been no imports, there would have been approximately 8% more jobs.

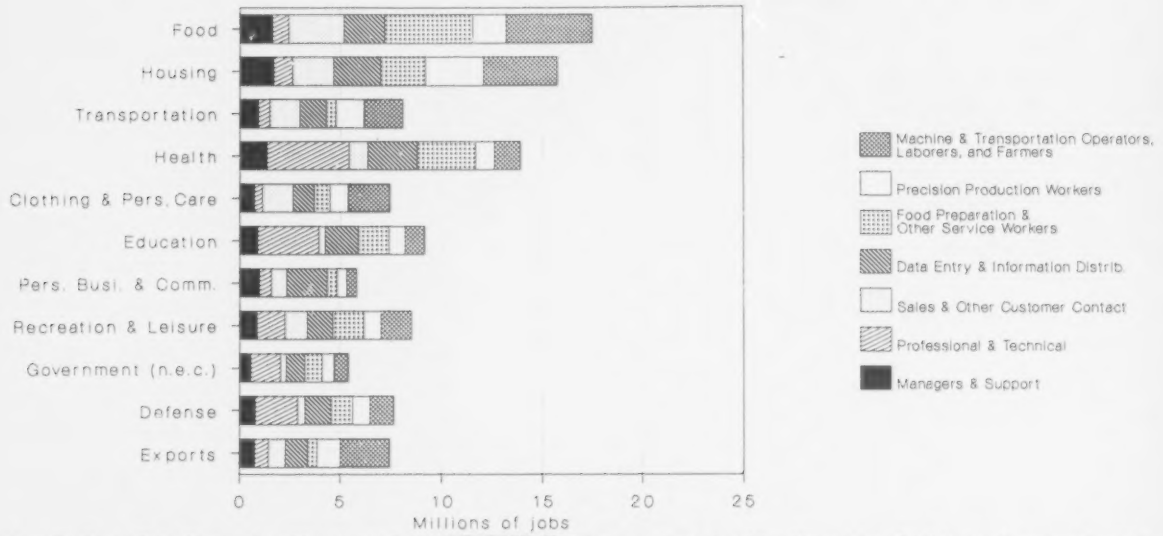
SOURCE: Office of Technology Assessment (see table 7-5 of ch. 7).

4. *People in Production Recipes.* The value that is added by each U.S. business depends on the contributions of employees with different kinds of skills. Figure 1-7 completes the network described at the beginning of this discussion by showing how effort by people with different occupations translates into amenity. Occupation is used as a proxy for skill since no other good substitute exists.

The American economy in 1900 allocated occupations to amenity very differently than the economy described by figure 1-7. A much larger fraction of all jobs would have been devoted to the production of Food and Clothing, for example, and a larger share of these jobs would have been directly involved with farming or other natural resources.

What might happen to such structures in the future? The method of analysis just described provides a systematic framework for examining hypotheses about changes in consumption recipes, production recipes, trade, and the use of skills in production. Public policy sets the rules under which choices are made in each of these four areas. These policies are discussed in greater detail in chapter 14.

Figure 1-7.-Jobs Required To Provide Amenity in 1984



How To Read This Figure: In 1984, the U.S. economy produced approximately 107 million jobs. Of this total, approximately 17.5 million jobs resulted from the production of food for U.S. households and government. Of these, approximately 1.6 million jobs were created for managers and management support occupations. All reported jobs in the U.S. economy are recorded somewhere in this figure.

SOURCE: Office of Technology Assessment (see table 10-6 of ch. 10).

Chapter 13 of this volume traces plausible hypotheses about changing choices in consumption recipes, production recipes, trade, and staffing by occupation. Figure 1-8 shows one of the many different scenarios examined. It represents an extreme case in that it shows what *could* happen if a major transformation occurred in each of the four analytical areas: consumption recipes that might improve amenity (for example, it assumes that investments in health promotion and disease prevention succeed); production recipes built around new paradigms (for example, it assumes a shift to a tightly integrated network connecting fiber production to retail apparel outlets); reduced reliance on trade; and a work force built around comparatively well-educated workers. It reflects comparatively rapid productivity growth with the real U.S. GNP rising at 3 percent per year.

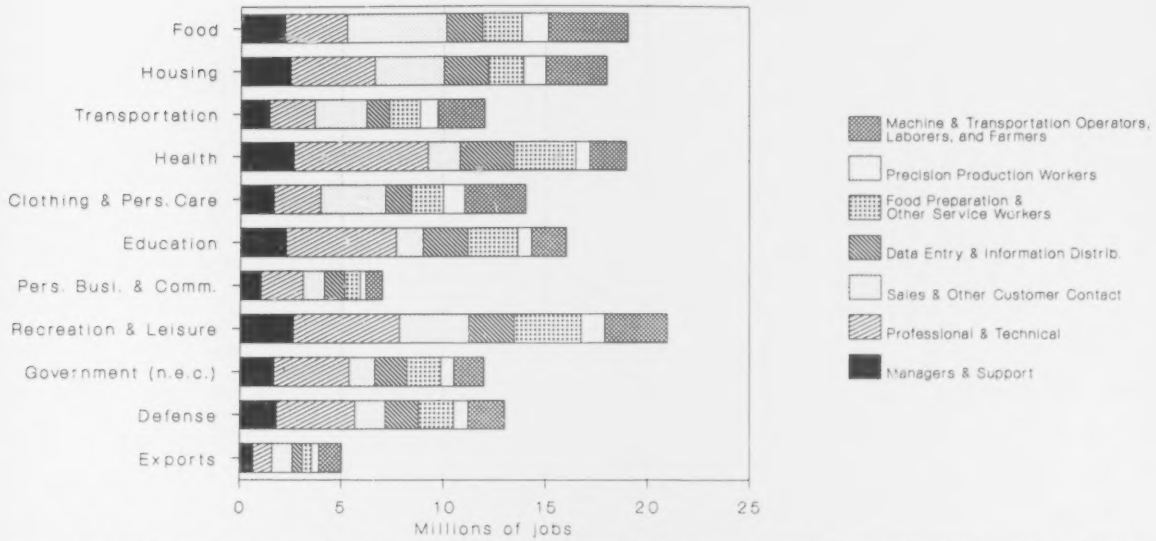
Under the hypotheses leading to the economy described in figure 1-8, productivity would greatly reduce employment in most mechanical jobs while employment in managerial, technical, and sophisticated clerical tasks would increase. Fewer people would be needed to provide basic materials or material processing. Many more would be needed to manage complex transactions and tailor products to individual needs. Since it is difficult to alter the productivity of tasks where direct human contact is essential, the share of all jobs required to provide education, entertainment, and basic government services (like fire, police, and other services) would increase in proportion to the rest of the economy.

Chapter 13 describes a variety of other scenarios. It may be possible, for example, to achieve high levels of amenity and a decline in the number of hours worked even though the dollar value of GNP grows comparatively slowly. There is no absolute way to measure the desirability of any of these scenarios.

Basic Characteristics of the Networks

Economic networks have been growing in size and complexity for some time. Each generation of new technology appears to increase the interdependence of businesses and individuals as well as the *number* of people and businesses tied together. Specifically:

Figure 1-8.-A Scenario of Jobs Required To Produce Amenity in 2005 (one of several considered)



How To Read This Figure: Several scenarios for the future structure of the U.S. economy are considered throughout this document. Under the assumption that significant, but plausible, changes occur in consumption recipes, production recipes, trade, and staffing patterns, this figure shows where jobs would be created in the U.S. economy in the year 2005. The format is identical to figure 1-7.

SOURCE: Office of Technology Assessment (see table 13-12 of ch. 13).

- Virtually no part of the economy now operates without heavy reliance on elaborate production networks. Production, marketing, sales, and transactional activities combine to deliver everything from frozen pizza to health care.
- Technology can increase the efficiency of a network acting as a whole as well as the performance of each enterprise in the network. Data provided by laser readers in grocery checkouts and improved communication systems permit efficient operation of tightly integrated networks of wholesalers, truckers, food processing firms, advertisers, and other businesses. This can be more important than efficiency improvements of any single business in the network.
- Taken together, new technologies can greatly increase the efficiency with which energy and materials are used. The efficiency gains, however, can typically only be achieved with increased spending for design and management.
- Intricate interconnections mean that problems and prosperity propagate quickly and affect many parts of the economy indirectly. Imports that affect a manufacturing firm also affect its web of suppliers. Exports create an elaborate trail of wealth.
- The new networks can have a surprising capacity for regeneration. New connections grow quickly when others are cut. Network components can shift rapidly to produce new products and services or to adopt new production strategies.
- Many of the networks have become international. Products, money, and ideas move about the world with new ease and speed. When production networks consist of many independent components, it is easier for both foreign and domestic businesses to enter.
- The complex networks have greatly expanded the role of transactional businesses—banks, lawyers, accountants, and communication specialists. Transactional costs can be measured by the increase in purchases of legal or financial services needed to make and enforce contracts, or

in purchases of other specialized business services. They can also be measured by the growth of management occupations and other transactional overhead costs in corporate bureaucracies.

- While disaggregated production networks could in principle spread economic activity widely in the United States, in fact they appear to have resulted in the concentration of economic activity in coastal cities. Businesses are choosing locations where they can find workers with adequate skills, and where extensive networks of personal contacts can be maintained. In the past much of American business needed easy access to natural resources.
- New networks are not only changing the relations between businesses, they are also changing the relationship between the market economy and the unpaid work done by family members. Capital investment in things like microwave ovens and video tape recorders ties households to food and entertainment networks in new ways. Child care, care for the elderly, and other "household" tasks are entering the market economy.
- People most likely to prosper in these networks are protean—able to change, adapt to unfamiliar work, and learn new trades as a continuous part of working experience. The talents needed are not clever hands or a strong back but rather the ability to understand instructions and poorly written manuals, ask questions, assimilate unfamiliar information, and work with unfamiliar teams. In short, the new networks require the skills provided by a solid basic education.

There is a paradox in all of this. Countries, establishments, communities, and individuals are finding themselves ever more tightly connected, and yet the networks allow more independence and choice. In particular, technology may tie production systems in different countries more closely together while nations may become less and not more dependent on imported supplies of energy, food, and manufactured products. The "green revolution" used technology to make many nations that were formerly food importers self-sufficient in food production. Material substitution and efficiency can reduce needs to import energy and minerals. In such situations the movement of materials may have decreased while the strength of linkages moving information, technology, ideas, and capital equipment has increased.

The shift to any new economic structure leads to effects resulting from the transition itself. These can often be difficult to distinguish from more lasting patterns of change. In a period of transformation one can expect rapid abandonment of older equipment (depreciation has grown steadily as a percentage of GNP), changes in business structure (rates of mergers, acquisitions, divestitures, and other transactions are extraordinarily high), and changes in demand for labor (there are large differences between the *average* job in the work force and the new jobs added during the past few years).

Policy Consequences

The depth of the changes underway in business networks, and the speed of change, requires a fresh look at policies designed to stimulate growth and mitigate the pain of adjustment. It is useful to divide options into two basic classes:

1. policies that affect the performance of the economy as a whole, changing rules in ways likely to facilitate choices made by consumers and producers; and
2. policies that facilitate the performance of specific networks like Education, Housing, or Health.

It is essential that the two policy strategies be coordinated. Policies designed to improve the performance of specific networks affect and are affected by programs designed to improve business performance through basic fiscal policy.

Analysis presented later suggests that production networks in diverse areas are becoming much more similar in the way they are managed, in the way they are linked to the rest of the economy, in the range of skills expected of employees, in the way they depend on the products of research and development, in the way they are regulated, and in the way they react to signals from the financial markets. Each network, however, retains unique features that must receive separate attention.

Programs designed to facilitate economic growth and expand the range of choices available to individuals can be built around the major elements of the network structure described in figure 1-2:

- The performance of *consumption networks* can be improved by providing individuals with more information, by ensuring that their education

is adequate to make informed choices in an increasingly complex society, by reviewing the incentives created by tax and regulatory policy, and by improving the way the government itself behaves as a consumer.

- *Production recipes* can be improved by changing the financial rules that may reward short-term profit taking over long-term investment, and by reshaping regulations that may place unnecessary constraints on the emergence of new production networks.
- The growth of *international production networks* makes it increasingly difficult to manage the economy in the absence of international coordination and cooperation. Regulation in areas as diverse as banking, communications, and antitrust needs to be undertaken with even greater attention to the way domestic networks are tied to international ones.
- Policy can influence the way employers use *people in production recipes* in a variety of ways. Policy can encourage employers to achieve flexibility through teams of skilled employees rather than by relying on "disposable" workers. A variety of incentives can be used to encourage compensation schemes that reward investment in training and that allow firms to adjust to hard times by reducing bonuses instead of laying off the most vulnerable employees. Policy can also encourage workers to be more flexible by reducing the pain of adjustment. Public investment and incentives can ensure employees access to training needed throughout a career. Retirement and health benefits can be made more transportable.

While the strategies are diverse, a number of themes emerge. Complex networks make centralized management of economic activity less feasible and less desirable. Networks in which productivity demands freedom to adapt and change may be impeded by regulation. This does not mean that planning is unwise, but rather that a new kind of planning is required. A firm confident in future demand for a specific product can plan to reduce costs through mass production. A firm certain that it cannot predict future demand must plan to have the flexibility needed to accommodate change.

The changing networks make it important to understand how the effects of public policy ripple through the economy. The flexibility of the emerging networks, for example, makes it comparatively easy for firms to evade conventional regulation. It can only become harder, and not easier, to define and regulate "banks," "emergency care facilities," "communication common carriers," or even "electric utilities." Restrictions applied to groups of products seem increasingly easy to subvert.

The problems associated with many kinds of traditional business regulation have led to an increased emphasis on programs designed to protect individuals rather than to regulate institutions. It is likely that this trend will continue. Steps can be taken to improve the information available to consumers as they make complicated decisions in areas ranging from health care to home purchasing. New rights to education, insurance, and pensions can be given to individual employees. New steps can be taken to ensure that markets take adequate account of safety, environmental, and other costs. These are difficult enough to regulate when production systems remain comparatively static. They are more so when systems are in flux.

Earlier economic transformations were associated with a major public investment in infrastructure: canals, railroads, electric lines, and highways. The transformation taking place today seems to require an entirely different kind of public involvement. An educated population is the most critical infrastructure of the emerging economy. It is critical for both the economic growth of the Nation as a whole, and the success of individuals acting as either consumers or employees.

Education has, of course, always been a central interest of American policy. Two things are new. First, the emerging economy places an unprecedented demand on the intellectual skills and knowledge of American workers. Old standards of competence are no longer adequate. Second, technology is making it possible to look for significant changes in the productivity and quality of teaching and learning for the first time. A system allowing any person, anywhere, with any background, and any assortment of gaps in education, access to training on any subject is within the state of the art of existing technology.

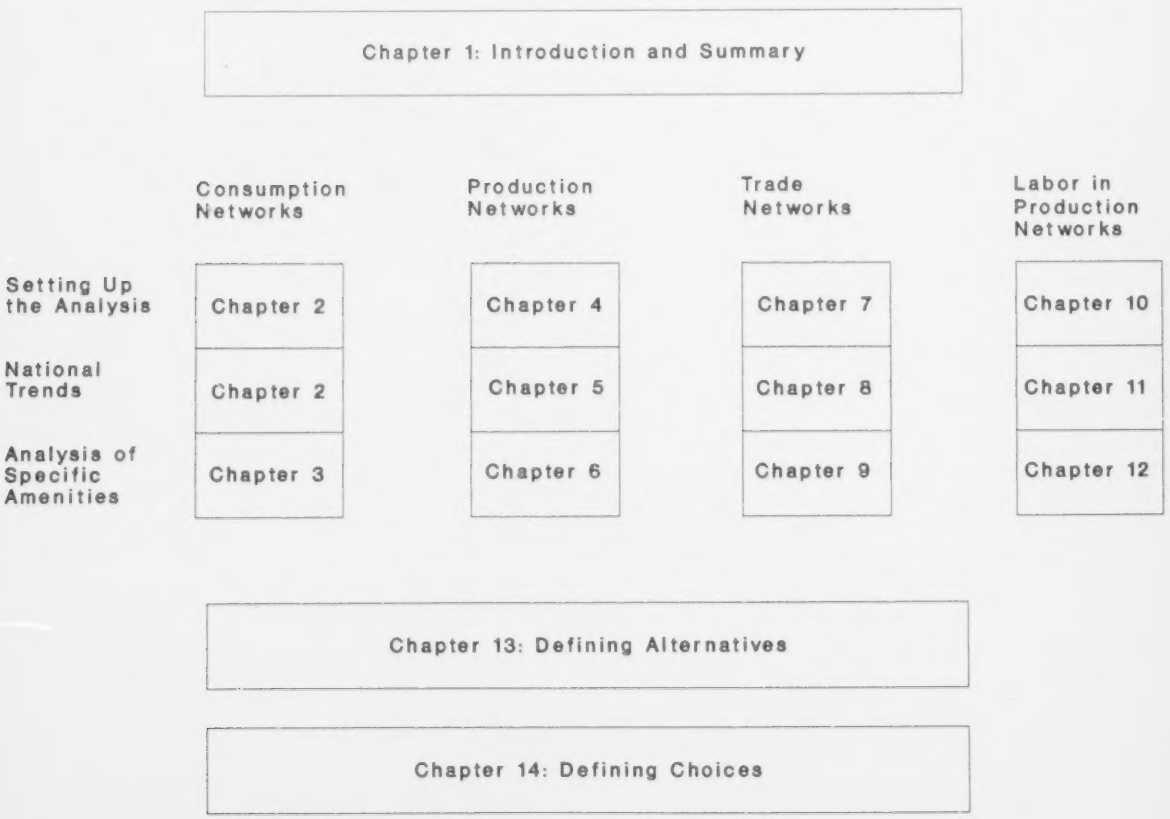
52-636 0 - 88 - 2 : QL 3

The Structure of the Report

It is obviously difficult to take a many-dimensional network and describe it in a linear prose essay. Figure 1-9 illustrates how the remainder of this document is organized. Each of the four major parts covers a different element of the American economic system. Each introduces a set of analytical tools for using national statistical series to look at economy-wide patterns of change. Each of the four parts, however, also contains a discussion of issues unique to each amenity network. These analyses are based on an enormous variety of sources ranging from national statistical accounts to specialized journals. The analysis of specific networks includes an effort to define progress in areas like Health and Education, a description of the peculiar features of each network, an analysis of trends in the way the network operates, and speculation about how it could operate in the future. These examinations include a review of changes in patterns of consumer and government purchases, changes in the way producers combine to deliver products and services (and the net productivity of these combinations), and changes in the way people with different skills are linked together directly and indirectly in these networks.

The final two chapters pull the pieces together. Chapter 13 develops a set of hypotheses about the future structure of the economy built from a series of specific hypotheses concerning consumption, production, trade, and labor. Chapter 14 reviews options for revising the regulations and incentives that shape the direction of U.S. economic growth.

Figure 1-9.-Organization of the Volume



SOURCE: Office of Technology Assessment.

SUMMARY

The following section provides a brief summary of the topics covered throughout the remainder of this volume. The reader is due two warnings before proceeding:

1. No attempt is made in this summary to provide references for facts or detailed arguments in support of conclusions. For this, the reader is referred to the sections of the report cited.
2. The discussions result in an assessment of strategic choices and provide a list of specific policies that could be used to implement these choices. The discussions of choice are divided into two parts. The first part outlines a set of public policy goals and objectives that grow directly from the analysis of this report. The second part, which suggests options for achieving these objectives, enjoys no such connection and has not been analyzed in any detail. *The options are offered to demonstrate that public choice can have a significant effect in moving the economy toward a desired objective. They are not intended to form a comprehensive list. Neither the costs nor the benefits of specific options are estimated in detail.*

THE NEW RULES

The rules under which the economy operates are being reshaped by four major forces:

- new technologies—primarily those built around microelectronics;
- the loss of U.S. preeminence in international markets;
- the possibility that the price of energy and other resources may increase sharply by the turn of the century; and
- changes in consumer and labor markets and a new attitude toward public regulation of economic activity, resulting—at least in part—from new values and tastes.

Taken together, these forces appear to open more opportunities than they foreclose.

New Technology

Technology has forced the U.S. economy through profound changes in the past and shows every indication that it will do so again. The introduction of steam power, railroads, and mass production equipment at the beginning of the 19th century serves as one example; the development of electric power, inexpensive steel, automobiles and telephones at the beginning of the 20th century provides another. These inventions did much more than improve on the way things had been done in the past. They changed basic conceptions about the limits of human ingenuity, removing seemingly insurmountable barriers. Moreover, they had effects going far beyond the markets for which specific inventions were originally developed. Each cluster of technologies led to rapid growth in wealth, standards of living, and employment. The texture of everyday life was transformed.

Weaving machines, for example, took work that had been performed in most households for generations and moved it to towns and factories. Inexpensive cloth improved comfort and sanitation and revolutionized fashion. New techniques used in the production of textiles and apparel turned villages into cities, changed the terms of international trade, and helped make England a world power.

The automobile quickly became more than just an improved horse. Affordable cars reshaped everything from the design of cities and suburbs to styles of courtship. They generated noise, pollution, accidents, poetry, and an unimagined range of personal mobility. A curiosity at the beginning of the century, auto production dominated U.S. industry by the 1950s.

Do the technologies now entering the economy have the potential to so transform society that their impact can be considered revolutionary? Can any of them do something that could simply not be done before, or reduce costs to a point where they can change basic paradigms of production throughout the economy? These are not easy questions. An overwhelming body of evidence suggests, however, that new technologies for collecting, storing, manipulat-

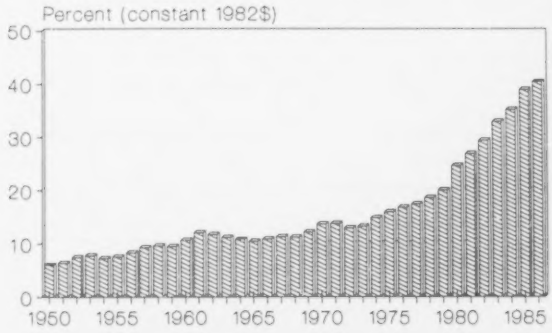
ing, and communicating information do have the potential to revolutionize the structure and performance of the national economy. They would have this potential even if the technology were to freeze at present levels—which it plainly will not. This is not to say that other emerging technologies will not also have a significant effect on the economy. Bioengineering can reduce the incidence of disease, extend life expectancy, reduce the cost of producing food, and improve the quality of American life in a variety of other ways. New materials can improve the performance of machines ranging from automobile engines to space stations. But while surprises are to be expected, it is likely that most of these technologies will do something familiar in a better way—at least during the next two decades. Information technologies have the potential to change the performance of the economic system itself.

If a revolution of some sort is underway, measuring its impact with any precision has proven to be exasperating. As in the past, technologies with the power to reshape the basic structure of production have effects where they are least expected and where official government statistics are poorly designed to chronicle the change (statistical series are usually best suited to chronicle the previous technical revolution). Some evidence of the astonishing impact of the new technology, however, can be seen in the fact that over 40 percent of all new investments in plant and equipment are now in a category called "information technology"—computers, copying machines, and the like. This is double its share in 1978 (see figure 1-10).

Much of this equipment is purchased by businesses specializing in transactions (law, banking, insurance, etc.), education, retail and wholesale trade, and in parts of manufacturing, health, and transportation traditionally associated with "overhead" or "margins." These are businesses where output cannot be measured in concrete terms. Convincing evidence of productivity growth has yet to be measured in many of these businesses. It is difficult to determine whether this is a transitional effect associated with learning during a period of massive change, a defect of measurement, or a real limitation of the technology.

The transitional problems associated with learning how best to use information technologies are

Figure 1-10.-Investment in Information Equipment as a Percent of all Investment in Producer Durables



How To Read This Figure: Measured in constant 1982 dollars, 40.4 percent of all producer's durable equipment (PDE) was spent to purchase computers, communication equipment, or related information equipment in 1984. About half of all investment in the U.S. is spent for PDE, the rest is used to purchase houses, and other construction products.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.7 (see figure 4-1 of ch. 4).

large. As was the case with earlier innovations, however, the more sophisticated information technology becomes, the easier it is to operate and the more widespread is its adoption. It would have been difficult for James Watt to believe that heat engines (in automobiles) could be operated by people unable to distinguish a wrench from a peony. Information equipment has made an important transition during the past few years. Computing power once confined to specially equipped, air-conditioned rooms has already insinuated itself into everything from automobile carburetors to greeting cards and teddy bears. Like the carburetor, the computer has become invisible for most users.

One of the problems of measurement is that information technology affects the structure of the economy in unexpected ways. Three areas appear to be of particular importance:

1. *Information technologies can increase the productivity of operations where real productivity changes once seemed so remote that they may never have been considered seriously.* Paper shuffling occupations provide a prime example. Clerical or quasi-clerical data entry, processing, communication, or manipulation is the principal

occupation of at least 16 percent of the work force (27 percent if managers are included). The potential productivity gains in this area—the movement and organization of information—are at least as great as those produced when the first Industrial Revolution began to revolutionize productivity in moving and transforming material objects.

Education provides another unexpected example. At least 8 percent of the work force is engaged in teaching. The new information technologies have the potential to increase the quality and the quantity of learning that occurs per unit of a student's time and per unit of teaching time. Quality means learning in greater depth. It means an ability to tailor teaching techniques to individual abilities and more time for teachers to talk to students.

Making full use of information equipment, however, requires a willingness to undertake a basic reexamination of management strategies and job descriptions. This is always a painful and uncertain process. Successful use of new information equipment seldom involves the direct replacement of a task by automation. Instead, entire operations (like data entry, filing, and routine management tasks) may be replaced with a combination of information equipment and jobs with new responsibilities (typically "quasi-professional" jobs involving clerical, interpersonal, and analytical skills). The potential for using technology in education depends on a willingness to reshape what is taught, where it is taught, how it is taught, the point in a person's career when it is taught, and the range of talents needed by the teaching staff.

2. *Information technologies have the potential to link production systems together in ways that improve the performance of entire networks.* These technologies can make it easier to serve large numbers of highly specialized markets. They make it possible to tie together complex networks of producers around the Nation or around the world by forging tighter links between retail, wholesale, transportation, and manufacturing operations. They also make it possible to concentrate production in areas where labor skills, wages, business conditions or living conditions are judged to be favorable.

Fundamental changes in management practices are needed throughout business networks if the full potential of the new technology is to be harnessed. Many such changes are already underway. Unprecedented scrutiny of management practices, inventory control, sales strategies, and other activities has already led to the growth of tightly integrated systems connecting manufacturers and business services. Tight networks now connect grocery stores to warehouses to food producers. Networks will shortly tie clothing retailers to apparel manufacturers to textile producers to the fiber industry. These changes impose a range of new demands on production technology and supporting services. For example, the new systems place a premium on rapid response and efficient batch production rather than on mass production. They place a premium on fast, reliable transportation of comparatively high-value products, rather than on low-cost transportation of bulk materials. As a result, they demand considerable support from service enterprises.

3. *Information systems can change the ways business performance and financial information are gauged, and can increase the rate at which markets respond to new business conditions.* Information technology that can make information both cheaper and easier to use can obviously have a deep, though subtle, effect on the efficiency of a free economy. It can affect both how producers organize their activities, and how consumers decide to spend their money.

Time-sensitive prices of such things as electricity can be continuously communicated to individual residences, for example. Businesses can also be made much more sensitive to market trends, and can tailor production planning more closely to market demand.

The international stock market crash of October 1987 provided a stunning reminder of the way that information processing equipment (facilitated by regulatory change) allows enormous amounts of money to shift hands quickly. The equations imbedded in the computer software conducting such trading do not just anticipate the performance of the national economic system but, to a major extent, have become part of the system. Regardless of whether this practice should be celebrated or condemned, there can be little doubt that information is influenc-

ing the way national capital resources are allocated.

New Challenges From Abroad

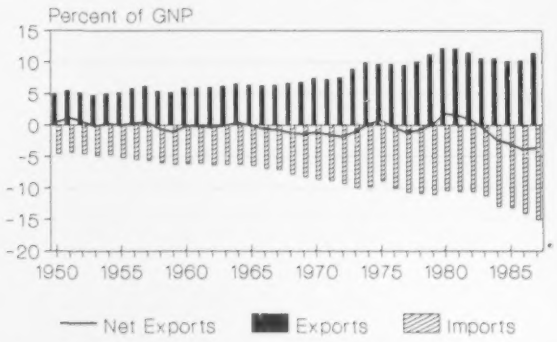
The networks that combine to deliver amenities to Americans have taken on an increasingly international dimension. Exports and imports nearly doubled their share of GNP during the 1970s (see figure 1-11).

The factors that make it possible for producers to divide production into separate steps in comparatively small establishments located across the country also make it possible to tie foreign producers into these networks. Once confidence is developed in foreign suppliers, it is easier for U.S. firms to expand operations abroad; once foreign producers establish a reputation for quality, they can build on this reputation. The process is cumulative and, barring catastrophic events, irreversible.

While the establishment of familiar links with foreign producers irreversibly opens the *potential* for foreign production, these links do not necessarily imply a continuing expansion of foreign production. Long transportation and communication lines add costs, both directly through increased shipping and inventory costs, and indirectly through inflexibility. Domestic ingenuity can be substituted for foreign supplies of energy and materials. It is entirely possible that the advantages of quick access to domestic markets and production links will offset any advantages of foreign production. This topic will appear repeatedly in this analysis.

The growth in trade over recent decades has resulted largely from the economic recovery of Japan and Western Europe following World War II. This recovery was, of course, a central goal of U.S. foreign policy for four decades—based on the sound belief that prosperity is a strong bulwark against Soviet destabilization. A second major factor has been the explosive growth of Korea, Taiwan, Hong Kong, Singapore, and other producers on the Pacific Rim who have developed rapidly, in large part because of their ability to offer competent workers with a sound basic education at low wages. In 1970, 40 percent of South Koreans of appropriate age were in the equivalent of high school. In 1982, 82 percent were enrolled. It also appears that the quality of the schooling received is high.

Figure 1-11.-Exports and Imports (percent of GNP in constant 1982$)



How To Read This Figure: In the third quarter of 1987, exports totaled about 11% of the U.S. GNP while imports totaled about 15%. The trade deficit was about 4% of the GNP.

*1987 third quarter.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 1.2 (see discussion in ch. 8).

The gap separating productivity levels in Japan, Australia, the United States, Canada, and major European economies has been cut in half during the past 100 years. This has meant a convergence in living standards, incomes, and labor costs.

There are some obvious reasons why followers gain on the leaders. Imitation is much easier once the basic paths have been revealed. Ideas flow rapidly—increasingly so, if some recent studies are to be believed—across international borders. Expanding economies are more likely to take risks with state-of-the-art production systems than established firms with large investments in existing equipment.

While loss of overwhelming U.S. dominance in world trade was expected, the rapid erosion of U.S. capabilities in advanced technologies was not. The theory of the "product cycle" seemed to explain U.S. leadership for many years. The theory was based on an assumption that U.S. producers operated in an economy with some of the world's most affluent consumers and best paid workers. Technologies developed for such an economy were unique, emphasizing high labor productivity and sophistication. As other nations approached U.S. living standards, and as the technologies involved became comparatively routine, they would naturally pass out of U.S. hands while U.S. producers moved to ever more sophisticated production.

This cycle has not only been slowed by the convergence of living standards, it may have been reversed. Foreign firms, recognizing that dynamic exploitation of technology is the key to international competitiveness, may have taken the lead. Having broken the product cycle, foreign producers are suddenly in a position to finance the next generation of technology with income earned from sales of the current generation. U.S. producers are left trying to leapfrog competitors without such a revenue source. In the case of consumer electronics, U.S. producers appear to have all but abandoned the effort. The rules of trade have changed in fundamental ways for U.S. producers. Increased linkages in the domestic economy also mean that trade problems in one area (e.g., manufacturing) quickly translate into problems in many parts of the economy (e.g., business service firms that owe a good portion of their livelihood to domestic manufacturing).

Loss of U.S. dominance does not mean that U.S. living standards will necessarily fall; indeed, living standards in the United Kingdom rose steadily for a century after it lost its dominant position in the world economy. It simply means that undisputed U.S. economic leadership may be lost. Certainly, it is now possible that the United States will find its living standards in decline with respect to its competitors, and discover its role as an economic and military leader of the free world called into question during the next two decades.

New Resource Constraints

The availability of natural resources once dictated the pattern of the U.S. economy. Today, as industries learn to make more with less and to substitute light, high-value products for heavy, cheap ones, far fewer firms are constrained by lack of resources. This is already altering the geography of U.S. industry in major ways.

But two natural resource issues will continue to demand attention: the availability of petroleum, and the limits of the environment's ability to absorb waste. Both can be surmounted given adequate planning. Without such planning, the comparatively heavy energy dependence of the United States could become a major liability. U.S. lifestyles would suffer if the price of petroleum increased suddenly (60 percent of U.S. petroleum consumption is for personal vehicles); furthermore, the comparative energy inefficiency of U.S. products (cars and appliances, for example) and production systems could make U.S. products less attractive in international markets and foreign products more attractive in U.S. markets. Resource policy leading to inefficient energy use can also lead to inefficient use of capital. Lack of attention to energy efficiency resulting from poor utility regulation, for example, can lead to massive diversion of capital to energy projects.

With current technologies, rising energy use translates into growth in solid waste and increases in air and water pollution. Fortunately, technology that improves the efficiency with which energy and materials are applied to products and services usually has the serendipitous effect of simultaneously reducing emissions. While energy use per dollar of GNP in the United States is still nearly twice that of Europe and Japan, it fell 25 percent during the 1973-86 period. U.S. consumption of steel, cement, paper, ammonia, chlorine, and even aluminum per dollar of GNP and per capita has either stopped growing or begun to decline. Electricity was the major exception to the trend, increasing nearly as fast as GNP since 1970.

New Values and Tastes

Another basic change in the rules involves changes in the tastes and values that motivate decisions in consumer markets, public spending, and labor markets. Changes in these areas have had dramatic and sometimes complex influences. Strenuous objections to nuclear power in the United States, the growth of the environmental protection industry, new interest in exercise and nutrition, and the growth of female participation in the work force have all resulted primarily from changes in values having little to do with economic forces.

Demographic and Social Factors

The size and structure of U.S. households and the role of women in the economy have both changed dramatically over the past decade. There has clearly been a change in the behavior that Americans find acceptable, and a consequent increase in the range of choices available for individuals. These changes come on top of an underlying pattern of demographic change of no small consequence. Taken together,

they have been responsible for qualitative changes in patterns of consumer expenditure and in labor markets.

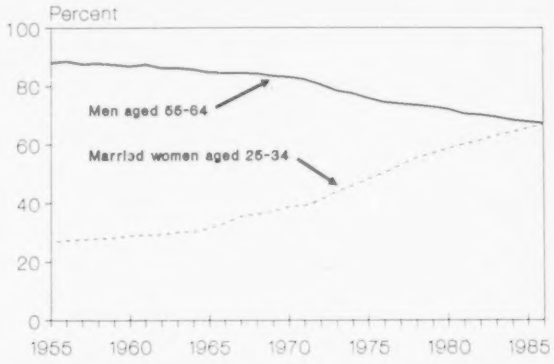
Those born during the baby boom recently left the Nation's educational system. They are now at an age to make major consumption decisions—decisions that often reflect changes in values from the generation they have replaced. This generation has created booms in a number of markets (such as increased spending on health, fitness, and travel), and in some areas this has led to congestion. Many young families are discovering, for example, that population pressures in areas where new jobs are being created have driven prices for housing to levels that are prohibitive for new home buyers.

This process is paralleled by a growing population of elderly people and a radical transformation in the size and structure of households. Divorces, late marriages, and growing acceptance of previously unacceptable living arrangements, such as single-parent households, have led to a rapid growth in comparatively small households. The average size of an American household fell from 3.3 people in 1960 to 2.7 in 1986.

Women are now much less likely to leave the work force even when they have young children. Many are forced to work since they are the sole source of support for their families. Moreover, the expansion of female employment opportunities has meant that women are much less willing to subsidize the economy with poorly paid work. Markets for nurses, teachers, and other traditionally female occupations have changed greatly as a result.

The increase in female participation has been offset by a sharp trend toward early retirement, resulting in part from more generous retirement programs and in part from a troubling trend toward the disposal of older workers for whom retraining is not judged to be profitable. Young married women are now as likely to be in the work force as older men (see figure 1-12). The number of hours worked in the economy by the average *adult* (age 16 to 65) seems to actually have declined during the past decade. Since the baby boom has recently increased the percentage of all Americans who are adult, however, the number of hours worked per member of the *total* U.S. population has increased.

Figure 1-12.-Work Force Participation for Older Men and Young Married Women



How To Read This Figure: In 1986, approximately 67 percent of married women aged 25 to 34 participated in the work force (e.g., were working for pay or actively looking for work). Approximately the same percentage of all men aged 55 to 64 participated in the work force.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics*, Bulletin 2217 (Washington, DC: U.S. Government Printing Office, June 1985); data since 1983 provided by the Bureau of Labor Statistics (see discussion in ch. 11).

Changes in Public and Private Regulations and Incentives

The phrase "regulations and incentives" is used throughout this document to mean the answer to the question "What explains the behavior of the individuals involved in economic activity?" These rules fall into two basic types: the profit motive of free markets, as modified by formal incentives and regulations promulgated by the government; and informal patterns of management that have evolved historically, often without reference to economic logic.

For better or for worse, both the formal and informal regulations governing the U.S. economy are undergoing changes that increase the freedom of American businesses. This is not a return to a halcyon past that was free of regulation. Most business activity was much more heavily regulated in the past.

Regulatory reform has eliminated or greatly reduced controls that once tightly constrained competition in enterprises throughout the economy. Many emerging technologies have the effect of reducing the size of economically competitive facilities. In some circumstances, privately owned phone

switches can compete with utility telephone switches, and cogeneration plants can compete with utility generation of electricity. Other technologies have introduced competition in areas once dominated by a single technology (such as alternatives to broadcast television and business communication systems). The result has been to undermine the logic of using principles of "natural monopoly" to regulate broad areas of the economy. Pressures of international competition are also destroying many traditional management mechanisms in businesses ranging from textiles to insurance.

While the logic of monopoly control may have been altered in many ways by the emergence of new technologies and demands for new network flexibility, the changes may increase the need for regulation to protect the health, safety, and privacy of *individuals*.

Perhaps the most critical question has to do with the motivation of individuals. Hard work, dedication, and inspiration cannot be entirely explained by looking at how a rational person would maximize income under prescribed rules. What keeps an inventor working through the weekend? The prospect of fortune plainly helps, but interviews with innovators continually suggest that much more is involved. A sense of pride, the admiration of colleagues and employers and, at least in traditional societies, a sense of contribution to a collective or national accomplishment all play a critical role. Interviews with entrepreneurs who left large firms to start their own repeatedly suggest that a desire for independence contributed as much as a desire to earn more money. Public or private rules that frustrate such intangible individual incentives are unlikely to promote real national growth.

CHOICES CREATED BY THE NEW RULES

The rules shaping opportunities for economic growth have changed in ways that undermine many basic paradigms for public and private management. Deep structural changes are underway in virtually every U.S. business sector. Some are painfully obvious: firms threatened by extinction in the face of foreign competition, or a health care industry revolutionized by new technology that has overwhelmed traditional means for managing health financing. In other parts of the economy, change is more subtle: an insurance industry in which products and production processes have been transformed by competition and new information technology, or a transportation system reshaped by new demands for speed, reliability, and quality in the delivery of comparatively small, lightweight products. Still other parts of the economy (education and home building, for example) remain comparatively stable, but there is potential for major change.

The choices created by the new rules are viewed from two perspectives: 1) structural change underway at the level of the entire economy and the policy choices presented by these changes, and 2) structural change underway in specific amenity networks and the choices presented by these changes.

Changes affecting the entire economy are measured by shifts in the relative role of different types of businesses (e.g., farming, manufacturing, and service enterprises), in the nature and volume of trade, and in the kinds of jobs created and lost. Choices exposed by an examination of economic performance at this level suggest a review of the incentives and disincentives created for businesses by laws affecting finance, trade, and labor policy. In many cases these signals seem incompatible with the course of action most likely to capture the opportunities of the new rules.

Changes in the performance of specific amenity networks can only be seen by examining the unique features of Health, Education, Transportation, and other sectors. Each require programs specialized to their unique problems and opportunities. Choices made about such programs work best when coordinated with programs designed to stimulate innovation and growth throughout the economy, and when made with a clear view of problems and opportunities shared by different sectors.

Economy-Wide Structural Change

The following discussion examines structural change in the U.S. economy by tracing changes at each of the four stages that connect people as consumers to people as employees and investors described in figure 1-2:

1. changes in consumer and government spending (consumption recipes),
2. changes in the way purchased goods and services are produced (production recipes),
3. changes in the way trade modifies these production recipes, and
4. changes in the use of people in production recipes.[2]

Each of these discussions lead to a distinct set of choices for public policy.

Consumption Recipes (Ch. 2)

The term "consumption recipe" is defined to mean the combination of private and public investment used to achieve an amenity like good health (see table 1-1). These recipes are based on a complex combination of logic and whimsy. They are shaped by changes in demographics, incomes, income distribution, prices, and by the emergence of new products and services. They can be strongly influenced by public regulation, tax policy, and information.

Describing Recent Trends.—American households are looking for—and finding—greater quality and diversity in products and services. This results in part from the fact that U.S. households are growing more diverse, and in part from the fact that technology and trade bring a greater variety of products to market at prices not significantly higher than those of "mass produced" goods. Technology also makes it possible to reach small markets efficiently.

While the rate of change in household types is likely to slow during the next two decades, the new diversity of American households will continue to shape demand for products and services tailored to a range of interests as the baby boom generation moves through middle age. Only one-fifth of households now have a working father, a housewife, and children, down from about one-third in 1972. Households headed by the elderly are increasing rapidly.

Changing incomes and income distribution also shape purchasing patterns. Higher income families, for example, tend to spend a higher fraction of their incomes on Recreation, Education, and Clothing and less on Food and Health. Demographic effects (particularly the increase in households headed by single women) and inequality in the distribution of property-type income has led to greater inequality in the distribution of after-tax income among families. While income distribution is obviously important for reasons of social policy, it has a surprisingly small effect on levels of relative spending in major consumption categories.

Direct consumer purchases of services are increasing. Much of the growth has been in the form of demand for financial services (including credit), hired substitutes for work formerly performed by unpaid household labor (like child care and care for the elderly), and increased expenditures on health care. A declining share of U.S. income has gone to purchases of Food, but the share spent on food-related services (primarily in restaurants) has increased over the past 30 years.

Purchases of energy and materials are declining as comparatively light, high-value products (such as personal computers) represent an increasing share of purchases. Purchases of heavy durables are leveling off. And people are buying more and more products tailored to their specific needs, from magazines to insurance policies. There has always been a demand for tailored services of this kind, and new technology is now making it possible to serve specialized markets by lowering the differences in cost that have traditionally made batch production more expensive than mass production.

Purchasing decisions also depend heavily on the availability of a person's time. Americans reported spending 108 minutes more per week in paid work, commuting, and household-related work in 1985 than in 1975; they therefore had less free time for eating, personal care, and other household activities (see figure 1-13). There was less time for housekeeping as well. Men did approximately 1 hour more housework per week in 1985 than in 1975, but women did about 5 hours less per week. Time avail-

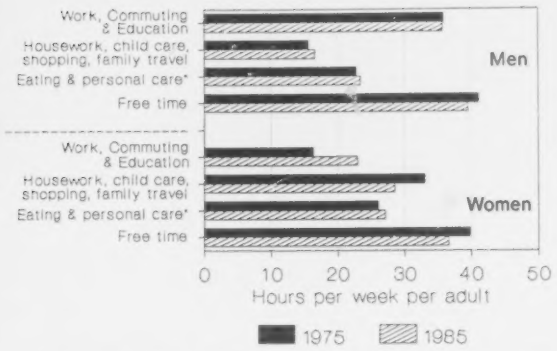
[2]The compensation and unearned income generated in step 4, of course, provide a basic constraint on purchasing patterns described in step 1. The analysis is designed to be internally consistent, but no attempt is made to produce a closed economic model.

Table 1-1.—Elements of the Consumption Recipe

Household purchases from labor and capital income
+Household purchases from transfer and other income
+Unpaid time of household members
+Government purchases of goods and services
=Total final demand

SOURCE: Office of Technology Assessment, 1988.

Figure 1-13.-American Time Budgets



How To Read This Figure: In 1975, American women 18 years of age or older had 40 hours per week for "free time" activities (organizations, social life, recreation, television and other electronic media, leisure travel, etc.). By 1985, this had fallen to 36.6 hours.

*Not including 7.5 hours/night.

SOURCE: Office of Technology Assessment (see table 2-3 of ch. 2).

able for leisure also seems to have declined in the past decade, in part due to the 40 percent increase in work-related hours. Women were affected the most, losing an average of 3 hours free time per week. Both sexes spent much less time spent socializing and participating in social organizations. There was even a slight decline in time spent watching television.

The mix of private and public spending used to achieve amenity has remained remarkably stable at levels that were shown in figure 1-3. There are some exceptions. For example, two-thirds of medical spending came directly from patients in 1950. In 1983, 73 percent of all spending came from insurance companies or government programs.

Strategic Choices.—An economy that increasingly takes the form of complex and interlocked networks can have the effect of putting more power in the hands of consumers. While the complexity of choice increases, the time available for making informed decisions is declining for many households. The joy of frivolous and capricious purchases and the principle of "caveat emptor" are obviously important driving forces in a free economy. Enthusiasm for them diminishes when it appears that ignorant consumers may place their health or savings at risk out of ignorance, or when the social costs of poorly informed consumers are high.

The high social costs of poor consumer choices can be illustrated by the following, admittedly extreme example: poorly informed consumers might buy air-conditioners that are much less efficient than ones that would have been purchased with the benefit of an informed analysis of the returns to an investment in higher efficiency. These poorly informed decisions would create a demand for electricity that is higher than would have been the case if all consumers were better informed. This, in turn, could force the construction of a new generating station, for which real returns to capital invested are much lower than the returns that consumers would have earned on added investments in air-conditioners. Leaving all other issues aside, the net result of such a series of events is an inefficient use of national capital resources.

New technologies can help to some extent by making it easier for consumers to sort out information. New information systems could even permit purchasers to play a more active role in designing products and services tailored to their personal needs, and even to receive "on-line" guidance about price trends in products and services of interest to them.

Policy can help improve consumption recipes in several ways:

- Regulations designed to protect consumers, which may have made perfectly good sense when first enacted, may have outlived their usefulness in areas ranging from banking to housing to electric utilities. Many of the specific issues are discussed in the individual amenity network discussions. Three principles, however, seem to have general value in reviewing how regulations might be rebuilt to facilitate the emergence of a more productive, restructured economy:
  1. Arguments about regulations governing the pricing of regulated monopolies, or those governing business entry or exit, need to be kept distinct from arguments about the need to protect consumers against fraud, unsafe practices, or environmental damage. Changing technologies may undermine the logic of regulated monopolies or elaborate programs of cross subsidies, but increase the need for government inspection and safety controls.

2. Subsidies for low-income groups are commonly used to justify regulation of transportation, housing, communications, and other major parts of the economy. They may, however, be inefficient ways of allocating public funds when a large portion of the subsidy does not end up helping the poor.
3. Standards for public regulation of hazards in the environment vary widely. High standards are set in one area (e.g., mobile source emissions), while other problems (e.g., indoor air) are largely unregulated. Contaminants in some kinds of foods are held to very low levels while others are more loosely regulated. In neither case does the response seem to correlate with levels of risk. It would be useful to have a uniform way to measure environmental exposure and associated risks from all sources—food, water, and air. There has been no comprehensive assessment of environmental regulation parallel to the omnibus review of the penal code that occurred several years ago.

- Labels can provide consumers with information not otherwise available for making intelligent choices. Energy efficiency labels on air-conditioners encourage consumers to consider energy costs when making an investment decision, much as miles per gallon labels help consumers make choices about cars. Warning labels on cigarettes and nutrition labels on food products also help in this process. There are many areas where labeling to give quality ratings could be improved, ranging from food products—where information about cholesterol, alcohol, sodium, saturated fat, and pesticide residues appears only voluntarily—to houses, where precise information about energy efficiency and other quality features is extremely hard to obtain.
- Personal income taxes strongly affect consumer incentives, by doing such things as making investments in houses (of any size) more easily deductible than investments in education. These priorities could be reviewed.
- The Federal Government, considered a consumer because of the peculiarities of standard accounting practices, can improve the way it makes critical purchasing decisions and can support research designed to improve its own productivity. Government buildings and vehicles are often less efficient than those purchased by the private sector. The U.S. Government, for example, pays more than $1 billion per year to subsidize heating for public housing—structures often having energy bills far higher than necessary. Major government enterprises, such as public education, are not backed by consistent research support or funds for capital investment.

Production Recipes (Chs. 4 and 5)

The term "production recipe" refers to the combination of products and services a firm purchases from other firms. It includes items from both foreign and domestic suppliers, and both capital equipment and supplies.[3]

Producing for the diverse and rapidly changing markets just described requires alert and integrated production networks. These production networks connect many kinds of manufacturing enterprises, service firms, transportation operations, wholesalers, and retailers. The performance of these networks cannot be measured effectively by looking only at the performance of component businesses—the customer sees the performance of the system acting as a whole. A trucking firm specializing in on-time delivery of comparatively small batches may seem to have lower productivity than another firm with lower charges per ton-mile. Yet the flexibility offered by the more responsive trucking service could reduce costs throughout a complex production and retailing network.

Describing Recent Trends.—Change in the structure of production networks is measured in three ways:

1. *Changes in the recipes used by individual businesses.* Each business creates a product by purchasing inputs from other businesses (materials, capital equipment, business services, etc.) and adds value of its own through the skill of its employees and the capital supplied by its owners (see table 1-2).
2. *Changes in the size of the establishments that comprise the production network, and in their ability to produce more than one product.* Ford's

[3]In technical terms, the "recipes" considered here include both fixed investment and intermediate inputs.

Table 1-2.—Components of the Production Recipe

Products purchases from domestic producers
+Products purchased from abroad
+Value added
Capital costs
Labor costs
Indirect taxes
=Total value of industry output

SOURCE: Office of Technology Assessment, 1988.

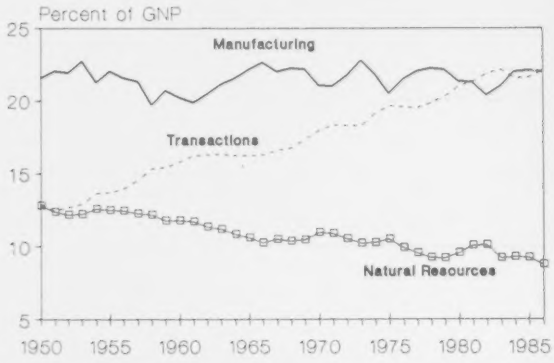
enormous Rouge River plant, which took raw materials in one end and pushed finished cars out the other, seems unlikely to be the model for future production. Instead, production networks are being organized in ways that defy easy classification. This applies to both the size of establishments and the size of firms that may own multiple establishments.

3. *Changes in the geography of production.* Changes in production networks can also be measured by shifts in the physical location of businesses. Changes in recipes, changes in the scale of manufacturing and service enterprises, and a variety of other factors have redefined the logic of firm location.

Changing Inputs.—New technologies, and the complex networks in part made possible by these technologies, make increasingly efficient use of natural resources and energy inputs. The decline in the share of GNP contributed by natural resource businesses (farming, mining, and energy) resulted mostly from a decline in domestic demand for their products (see figure 1-14).

The declining share of natural resource businesses is more than offset by growth in transactional businesses (law, finance, insurance, business services, etc.). Between 1972 and 1984, these gains were almost equally divided between increases in consumer and government demand and increased use of transactional activities as inputs by other businesses (see figure 1-15). The rising use of transactional inputs results in part from increased demands for information, and in part from the fact that the management of these networks has become more complicated—the emerging networks require both more complex external contracting and more complex flows of products and information within firms. The three fastest growing direct inputs into the Nation's production processes are wholesale and retail

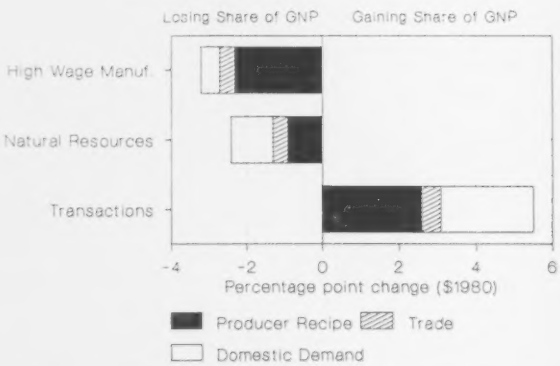
Figure 1-14.-Shares of GNP
(in constant 1982$)



How To Read This Figure: Measured in constant 1982 dollars, the fraction of the gross national product contributed by farms, mines, energy companies, and other natural resource businesses fell from 12.8 percent in 1950 to 8.7 percent in 1985. The share contributed by manufacturing appears to have remained close to 22% during the entire period but there is reason to believe that some of the procedures leading to this estimate are flawed (see chapter 5).

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.2 (see figures 5-2b, 5-3b, and 5-4b).

Figure 1-15.-Explaining Changes
in Sector Shares: 1972-1984



How To Read This Figure: Between 1972 and 1984 the percent of the U.S. GNP produced by Natural Resource businesses fell 2.4 percentage points. Changes in household and government demand reduced the share by 1.1 percentage points, changes in trade reduced the share by 0.4 percentage points, and changes in the production recipe of businesses reduced the share by 0.9 percentage points.

SOURCE: Office of Technology Assessment (see table 5-1 of ch. 5).

trade services, business services like advertising and consulting, and communications.

While the contribution of manufacturing appears constant in figure 1-14, its share of overall employment has been falling rapidly. Calculations showing that manufacturing commands a fixed share of the GNP, however, depend heavily on techniques used to adjust for inflation. Half of the growth in manufacturing's contribution to GNP estimated for the 1980-86 period resulted from the difference between the inflation adjustment for computers and other information equipment and the average adjustment made for all U.S. businesses. Techniques discussed in chapter 5 suggest that the part of manufacturing paying the highest wages (such as the automobile and steel industries) may have fallen as a percent of GNP during the past few years, resulting in an overall decline in the share of manufacturing. Deficiencies in available data leave the issue clouded.

International trade had a relatively minor effect on the changing GNP shares of most sectors in the U.S. economy before 1980, but has since had an effect nearly as large as shifts in domestic demand. The negative effect of trade was felt most heavily in manufacturing. Transportation, wholesale and retail trade, and transactional services all benefited from trade because many of these enterprises gained business from exports.

There is no good index for measuring the growth of networks. One way is to see how much business a firm generates for its suppliers. An economy-wide index of linkage based on this concept increased 5 percent between 1972 and 1980.

While the entire economy became more tightly linked during this period, conflicting forces are at work. The links connecting manufacturing firms to the rest of the economy, especially to the service sector, seem to be growing: the linkage index for manufacturing industries paying the highest wages increased 15 percent between 1972 and 1980. On the other hand, the transactional businesses gaining share in the economy are not very highly linked to other parts of the economy, since a large fraction of their sales result from their own "value-added" (rather than from the cost of inputs purchased from other firms). On average, manufacturers keep only about one-half of the value of their sales in the form of profits or wages paid to employees—paying the rest to their suppliers. In contrast, service firms keep nearly two-thirds. Service businesses are linked to the rest of the economy primarily through purchases of capital goods, such as buildings and computers. In 1984, demand for manufactured goods generated approximately 6.3 million service sector jobs—about 1 out of every 11—while demand for service products indirectly created about 4.3 million manufacturing sector jobs—about 1 out of every 5.

Changes in Scale and Scope.—Given the striking transformations underway in production networks, it is not surprising that many traditional management strategies are under intense scrutiny. The prevailing wisdom about the optimum size of production facilities, relations to domestic and foreign suppliers, and investment in research and new production technology is being challenged across a broad front. As expected, responses from established management vary from enthusiasm to intransigence. In some cases it seems to swing wildly from one pole to the other.

There is much debate, and no convincing data, about the kinds of business structure that will prove most successful in the emerging economy. Indeed the very vocabulary available for describing the different formal and informal business networks and management strategies being tried proves to be inadequate. It is obvious that an enormous amount of experimentation is underway. Many large firms are adopting a management style that allows subsidiaries to act with greater independence. It is common to find many establishments owned by a large firm that provides services such as communication networks, billing, advertising, and personnel management. Clusters of small firms can operate under the umbrella of a larger firm (e.g., suppliers to computer industries).

Under the pressure of intense domestic and international competition, the marketplace should soon provide some clarifying signals. In the meanwhile, there is great confusion over whether smaller enterprises are more flexible, more innovative, more likely to invest in long- or short-range research and development, or more likely to be attractive places to work than larger, more bureaucratic institutions. Economies of scale in individual establishments appear not to be as much of an advantage as they once were. Indeed, there appear to be diseconomies if es-

tablishments become so large than management loses touch with employees. Rigidly managed larger firms have suffered from an inability to move quickly to exploit new market niches and new production technologies. In their attempts to impose uniformity, such firms may be unable to learn from their employees. On the other hand, the larger firms can sustain major development projects requiring large, long-term investments. They can also be better employers, offering employees more benefits and more job stability.

One measure of the rate of restructuring can be found in the surge of mergers, takeovers, and divestitures that have taken place in the past decade, made possible by reduced regulatory restrictions (see figure 1-16). Hostile takeovers represented only a small fraction of the total. The net result of mergers, and of patterns of new business formation and bankruptcy, has been a change in the size of the average U.S. establishment and in the range of products that it produces.

Management styles seem to be converging across the U.S. economy. Large farms, for example, are being managed as sophisticated, heavily capitalized enterprises. The owner is often, in effect, a professional manager. The construction industry is increasingly resembling a manufacturing enterprise, with more components assembled in factories. Fragmented "low-technology" enterprises, such as those found in the textile and apparel industries, are becoming consolidated and are coming to depend heavily on advanced production technology. Large integrated facilities, such as those in automobile production, are moving toward smaller establishments and shorter production runs. Large banking and insurance businesses are investing heavily in computer and communications equipment. Hospitals and groups of physicians are moving toward professional management, with physicians as paid employees. Schools may move toward a more differentiated teaching staff and increased capital investment.

Figure 1-16.-Mergers and Takeovers, 1972-86 (constant 1982$)

How To Read This Figure: In 1986, the value of mergers and takeovers totaled more than $150 billion (1982 dollars), up from $40 billion (1982 dollars) in 1972. The value of takeovers considered hostile totaled about $30 billion in 1986.

*Data for hostile takeovers not available prior to 1982.

SOURCE: Julius Allen, "Corporate Takeovers: A Survey of Recent Developments," U.S. Congressional Research Service report No. 87-726-E, Washington, DC, Aug. 6, 1987; and Carolyn Kay Brancato, "Merger and Acquisition Activity: The Level of Hostile Mergers," U.S. Congressional Research Service report No 87-507 E, Washington, DC, June 16, 1987 (see discussion in ch. 5).

In 1984, 73 percent of all manufacturing employees worked in establishments employing more than 100 people, a 2.3-percent decline from 1982, while only 40 percent of employees in finance, insurance, and real estate worked in establishments with more than 100 employees (up 3.2 percent). Nevertheless, enterprises with fewer than 100 employees added 47 percent of all jobs gained by the economy between 1976 and 1984, even though they supplied only 37 percent of all jobs in 1976. The largest gain in employment share between 1978 and 1982, however, was in small establishments of large enterprises.

While small firms have generated a growing percentage of all jobs, they appear to generate a decreasing share of output. Businesses with 20 to 500 employees increased their sales annually by 4.3 to 9 percent between 1976 and 1982, while firms with more than 10,000 employees grew at 16 percent. Part of this growth can be attributed to recent acquisitions and mergers. The strategies behind the mergers are frequently difficult to ascertain since most recent mergers have been classified as "conglomerates," a category that includes both mergers made to achieve system-wide productivity gains and mergers that represent portfolios of convenience for speculators. While only 50 percent of mergers were classified as conglomerate in 1950, 90 percent were classified this way in 1979.

Mergers tend to make the parent firm more diverse. Between 1963 and 1982, the number of different products made by a single manufacturing firm increased 15 percent. At the same time, establish-

ments that are a part of larger firms have become more specialized. The number of different products made by single manufacturing establishments declined by a factor of 3 over the same period.

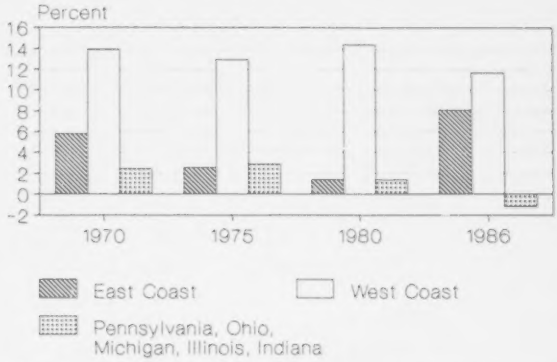
The Geography of Production.—A map showing such natural features as rivers and harbors, or even minerals, no longer says a great deal about where economic activity will occur in the United States. New forms of communication, declines in the scale of individual establishments (in both manufacturing and services), a decline in the resource demands of manufacturing, movement of jobs from the shop floor to offices, improved flexibility and responsiveness in transportation, and a variety of other factors remove many of the constraints that formerly limited choices about business location.

The theoretical possibility of locating a manufacturing or back office service firm virtually anywhere has, however, apparently been more than offset by other factors. The attraction of locations offering a well-educated labor pool (even where this means higher taxes), and access to major research centers and financial institutions, increases as other constraints on location diminish. A survey of "high technology" manufacturing firms taken in 1982 indicated that "access to raw materials" was 12th in a list of 12 reasons for selecting a plant location. The availability of skilled labor topped the list, ahead of concern about labor costs. Moreover, rapidly expanding businesses, such as banking, insurance, law, and real estate, still depend on networks of personal contacts and communications. This often translated into a decision to locate new facilities in the immediate vicinity of urban centers: New York, San Francisco, and more recently Los Angeles, Dallas, and Houston. The excitement and variety of these areas are plainly also a lure.

The result has been an increasing concentration of employment, particularly high-wage employment, around major metropolitan areas of both coasts (see figure 1-17). Indeed, there has been rapid movement of economic activity down the east coast, from Boston to Miami; continuing expansion in Texas, Arizona, and southern California; and continuing losses of population and economic activity in the rust belt regions of the northern midwest.

While inequalities in regional incomes declined during the 1970s, the decline appears to have stopped.

Figure 1-17.-Regional Wages: Percent Above or Below National Average



How To Read This Figure: In 1986, wages in States bordering the Atlantic coast were 8.1% above the national average and wages in States bordering the Pacific coast were nearly 11.7% above average.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Information System," tables SA1, SA2, and SA3, unpublished, August 1987 (see discussion in ch. 5).

In fact, during the 1980s New England and the Pacific coast regions appear to have regained their significant lead in average incomes. Incomes in Ohio, Illinois, Indiana, Michigan, and Wisconsin, which were above the national average in 1970, are now below average. Although they remain below the national average, incomes in States on the southern Atlantic coast showed a steady gain from 1970 to 1985. The southern Appalachian and Gulf Coast States, however, have incomes that remain 20 to 25 percent below the national average—a position unchanged since the 1960s. On the whole, the economies of the U.S. coastal States appear to be prospering, while the center of the Nation falters.

It is difficult to account for the continuing attractiveness of coastal cities and the failure of U.S. companies to move to low-wage regions. Employers appear to be willing to pay a premium for access to people with good training and job skills, and use their new mobility to pay lower wages to relatively well-trained people abroad. An employee in Taiwan with a solid high school training in mathematics, for example, costs far less than a person with a mediocre education in the United States.

With the exception of New York, most of the growth has occurred in centers associated with a major city but not in the traditional core of the city. Pop-

ulation shifts to the suburbs have allowed many people to live in relatively inexpensive areas while keeping commuting times reasonable. However, this has also made public transportation virtually impossible. And since the headquarters of most major firms are usually located in downtown areas, movement to suburbs may have blocked contacts critical for career advancement. Suburban business growth can also create problems for mid-level minority workers, many of whom cannot afford to live in suburban areas and are unable to commute there on public transit.

Population has followed economic activity, and Americans remain extremely mobile. Only half of the population lived in the same house in 1985 as in 1980, and one-third had moved from a different U.S. county or a different country. A survey of movers in the early 1980s indicated that the 50 percent moved to take a new job or military assignment. Nearly one out of every six people classified as "displaced" between 1981 and 1985 moved. Surprisingly, the highest percentage of displaced workers who moved were not the youngest workers but those aged 45 to 54.

Strategic Choices.—It is apparent that a deep structural transformation is taking place in production networks. Trends are difficult to read because of complex patterns of experimentation. The challenge of policy here is to create a system of rules that encourages experimentation, transformation, and growth without sacrificing the traditional responsibilities of government to provide protection against monopoly abuse and protection for individuals and communities forced to bear the burden of adjustment.

The challenge is to find practical ways to enjoy the advantages of competition and "creative destruction" in fostering change, while minimizing the risk that such a process will destroy the ability to engage in long-term development work. There is no magic way to do this. The most promising places to look for solutions are first in the financial rules that guide investment decisions, and second in research and development policy.

Financial Rules.—The rate at which constructive changes are made in production networks, as well as the kinds of networks created, depend heavily on the financial rules under which investors operate. Typically, failure of the U.S. financial system does not occur in its support of invention or innovation. The United States continues to lead the world in many research fields, and has a strong venture capital community. Problems seem to develop when hundreds of millions of dollars must be found for comparatively risky projects that require many years to reach maturity; in effect, the system seems to fail once the invention in the garage starts working. Public policy in areas like tax law, as well as the techniques used to evaluate managers, can influence the planning horizon of investors and businesses. Some financial instruments are obviously keyed to very short-term, speculative trading that is only weakly tied to the long-term interests of a firm. On the other hand, the pressure of aggressive financial markets is necessary to ensure effective management of national capital assets. Takeover threats and the potential for stockholder rebellion can provide a defense against inattentive management.

The following policy options may improve the mix of patient capital and effective competition for capital resources:

- Tax reform:
  - —reduce or abolish income tax paid on capital gains from assets that are held for more than 3 years;
  - —limit the deduction for housing interest to a fixed amount;
  - —reform or abolish the corporate income tax (it contributes only 7 percent of government revenue; its complexity distorts private investment decisions; the transactional costs associated with tax compliance are high; the tax acts as a non-progressive sales tax for U.S. consumers; and it increases the cost of U.S. exports).
- Reform of the system regulating financial institutions (limitations on merchant banks, for example), which could allow for greater diversity in capital assets available to corporations and could encourage more long-term plans for new products and production networks.
- Reduction of transactional costs, by developing better techniques for combining regulation, negotiation, and freedom to sue for damages.
- Review of priorities for the $200 to $300 billion in federally supported loans and loan guarantees now largely directed to housing and agriculture.

Research and Innovation.—A competitive and prosperous economy depends both on a system of incentives that encourages investors to make money from new ideas, and on a continuous supply of new ideas; neither is adequate in itself. Research and innovation play a growing role in the health of every sector in the economy. Even areas where research has not traditionally played a major role (e.g., home construction and apparel) are likely to find their productivity and competitive position strongly influenced by the ability to conduct and absorb the products of research. It is essential that the United States improve on the way it combines corporate and public resources in the pursuit of innovation. Like education, this is an area where government expenditure should be considered as investment and not consumption.

There are many areas of pure research that cannot be sponsored by corporate funds because of the high risks involved. Also, areas of applied engineering can play a crucial role in national economic development, but their value is likely to be spread so broadly that no firm can expect to regain its investment in full.

The challenge is to find ways of spending public funds in a manner that neither competes with existing private innovation nor disappears in pursuit of white elephants. Two basic strategies deserve attention:

1. *Cooperative Research Facilities.* Measured in terms of the development of inventions that have provided a key to world economic growth, Bell Laboratories surely was one of the best research facilities in the history of the world. It has, of course, been largely reorganized following the breakup of the AT&T system. A variety of mechanisms have been proposed for building laboratories of this quality around clusters of pure and applied research issues:
   a. a mechanism for mingling public and private funds in ways that allow public disclosure of discoveries affecting the common interest, while permitting private firms to maintain rights to specific proprietary ideas;
   b. a reputation for research excellence that would attract the best people in the field (it may be necessary for the facility to be associated with a degree program at a major university);
   c. research freedom adequate to permit exploration of novel ideas, coupled with a set of general themes tied to practical markets;
   d. a way to disburse funding through grants and venture allocations to small research groups;
   e. a way to combine academic research with research keyed to practical needs that does not compromise the intellectual freedom of universities; and
   f. a way to encourage research capable of improving productivity in business services (since service productivity is of growing importance to overall economic growth).

   The Bell management provided guidance on the balance between pure and applied research. Research ventures pooling resources from many firms could be managed by a private board with an interest in seeing that funds are well used.

   A number of sectors of the economy do not conduct significant amounts of research and might benefit from a coherent research program, such as new technologies for learning and teaching, residential construction, and textiles and apparel. Government itself is a major information enterprise, and could justify research designed to improve the net efficiency of data processing and communication within its own bureaucracy. This, coupled with a careful procurement policy, could work to stimulate efficiency in private firms and to encourage new information technology.
2. *National Goals.* Research in some areas could be stimulated by the clear articulation of a national vision—a goal with the power of the space program that could be accepted as important by all Americans. Candidates include a Learning Research Institute, the renewal of space exploration, or even the development of a radically new form of personal transportation. Such projects are, by definition, impossible to justify on the basis of a purely rational calculus of cost and benefit. But they can couple public imagination and support of private genius in ways not otherwise possible. Properly constructed, the project could provide a home for a variety of research efforts and a market for many of the products of research. Defense-related projects can focus research efforts, but they may not be an adequate substitute; security classification, specialization in areas without clear commer-

cial applications, and other factors limit the extent to which defense research facilitates opportunities for civilian economic growth.

International Connections (Chs. 7 and 8)

Describing Recent Trends.—Production networks have always operated across international borders. In the past two decades, however, the networks connecting the United States to the rest of the world have changed in both size and scope. Nearly 7 million American workers now owe their jobs to exports, a percentage that has nearly doubled in a decade. Because of the large trade imbalance, however, U.S. employment might have been 10 percent higher in 1984 without imports.[4] Figures 1-5 and 1-6 showed that trade has entered virtually every production network and has had a significant impact on virtually every U.S. business. The few areas that are not already involved heavily in trade (home construction, for example) may soon find themselves parts of international production networks.

If nothing else, trade creates direct competition between American styles for managing networks and those of other countries. Until very recently, it could comfortably be assumed that American firms would be at the lead in development of new products and labor-saving technology. America led the world in both supplies and demand for innovation. American commitment to research and innovation was strong, and America had the most affluent consumers and most expensive labor. Forces driving both supplies and demand, however, have changed rapidly during the past few years.

The ambiguity about whether new technology would encourage geographically dispersed production networks in the United States (as seems theoretically possible), or would lead to further concentration in favored regions translates directly to ambiguity over the effect of technology on trade. In some cases, technology has encouraged the spread of economic activity:

- The complexity of production networks, and the decline of large production establishments, has allowed more points of entry for foreign products.
- The declining significance of resources, and the growing importance of a firm's ability to manage innovation, has made it possible for alert and aggressive foreign firms to compete successfully in U.S. markets.
- Communication and efficient transportation of lightweight, high-value products makes it possible to tie diverse networks together. Advanced telecommunication equipment has created worldwide financial networks.
- The previous discussion showed how technology can affect the scale of production. It proves difficult, however, to demonstrate the effect of scale on international competition. Anecdotes can be provided showing how small, entrepreneurial U.S. firms have fallen victim to large, patient, bureaucratic foreign organizations (e.g., producers of semiconductors). Examples can also be found where small, aggressive foreign firms entering U.S. market niches have beaten bureaucratic firms in the United States (e.g., manufacturers of textile machinery).

There are also reasons to believe that technology may undermine trade and exaggerate, rather than shrink, the difference between living standards in rich and poor nations:

- Technology capable of making efficient use of energy and material resources can limit needs for world trade in these products.
- Technology capable of making small batch production nearly as efficient as large mass production can reduce the advantage of large plants producing for world markets.
- The growth of niche markets, and of domestic production networks requiring rapid movement of products between establishments, can increase the advantage of proximity.
- Networks connecting retailers and producers in ways that minimize inventories depend on an ability to respond quickly to changes in markets—this increases the value of producing in locations physically close to the market served.

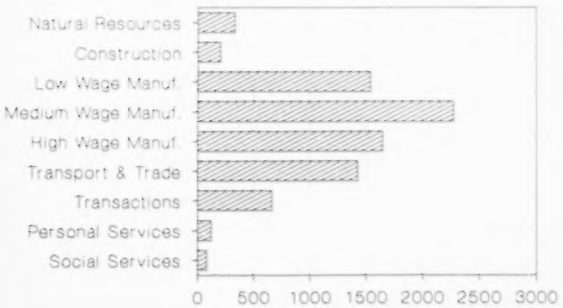
Changing Comparative Advantage.—Under ideal conditions, the economics of trade should encourage each nation to specialize in the production

[4]These estimates, and many that follow in this summary, are based on an input/output analysis approach discussed in chapter 7. They must be treated with great care. Obviously, it is difficult to estimate how the economy would operate without imports since the price of domestically produced items is different. Assumptions needed to make the estimates, and the limitations of the methods, are discussed at length in chs. 4 and 7.

of goods and services that its firms make at *comparatively* low cost. If the ratio of exports to imports of a given product decline, trade may have revealed a decline in the nation's comparative advantage in that product or service. While real international markets fall far short of the ideal markets that in theory would reveal comparative advantage, since national policies frequently shape trade patterns, it is useful to see what the record shows about changes in America's comparative position in different areas.

Trade forces attention to the links connecting different parts of production networks. Figure 1-18 shows, for example, that a significant fraction of all jobs hypothetically lost from U.S. imports of manufactured products in 1984 were lost in service enterprises that played a role in production networks. About 1.5 million jobs in transportation and trade and over 600,000 jobs in transactional activities were lost indirectly because imports displaced domestic manufacturing activity. All told, 4 of every 15 jobs hypothetically displaced by imported manufactured goods are in the service sector.

Figure 1-18.-The Jobs Lost Because of Imports of Manufactured Products in 1984 (illustrating trade linkages)



How To Read This Figure: Imports of manufactured products in 1984 resulted in the loss of 1.5 million jobs in Low Wage Manufacturing industries, 2.3 million jobs in Medium Wage industries and 1.6 million jobs in High Wage Manufacturing businesses. The loss of business for manufacturing, however, also creates losses for businesses that supply manufacturers with resources and services. Imports of manufactured products in 1984, for example, resulted in the loss of 300,000 jobs in Natural Resource businesses and 660,000 jobs in Transactional businesses.

SOURCE: Office of Technology Assessment (see table 7-10 of ch. 7).

Considering both direct and indirect effects, trade appears to have reduced business for nearly all U.S. "high technology" production between 1972 and 1984. Chemical products was one of the only industries that gained in relative rank between 1972 and 1984, while businesses in electronic components, office and computer equipment, engines, aircraft, and other technology-sensitive industries lost rank. In general, 18 of 20 industries designated as "high technology" lost rank over this period. Businesses with heavy natural resource components (i.e., lumber, leather, tobacco, and paper) gained rank, as did service and support businesses.

Measured from the perspective of occupations gaining or losing advantage from trade, manufacturing employees lost in comparative terms between 1972 and 1984 while lawyers, communication equipment operators, and farmers gained rank. Of all "hand working," "machine setting," and "precision production" jobs in 1984, 23 to 32 percent were displaced by imports. These occupations, however, also gained the most from exports, with 12 to 17 percent of their 1984 jobs resulting directly or indirectly from exports. The period showed a sharp break between the way engineers and scientists were affected by trade. Scientists benefited from changes in trade, while engineers were among those most heavily disadvantaged. Had all imports that could be manufactured in the United States in 1984 been so manufactured, there would theoretically have been 21 percent more jobs for engineers. On the other hand, 14 percent of U.S. engineers owed their jobs to exports. Natural scientists, computer experts, and mathematicians were less heavily affected, with a 12 percent loss from imports and an 8 percent gain from exports. The occupations least affected by trade were in services (i.e., teachers, health services, clericals, and sales personnel).

Strategic Choices.—It is theoretically possible for trade to improve living standards throughout the world, but this promise remains clouded by the stubborn realities of nationalism, protectionism, and distrust. The central objective of trade policy must be to make trade a positive sum game for all participants, including the United States.

Even in the best of circumstances, the theoretical advantages of free trade can be demonstrated only for the average American over the long-run. There

will be winners and losers as trade expands production networks across international borders. A second objective, therefore, must be to find ways to share the pain and the advantages of trade as widely as possible. At a minimum, no group should bear the bulk of the burden of adjustment.

It is worth beginning by being clear about some of the problems associated with trade even under favorable circumstances:

- Expanding trade increases the difficulty of managing the domestic economy without international cooperation.
- Expanding trade takes jobs from the individuals with the lowest skills in the United States, and increases uncertainty throughout the economy. Trade has a comparatively large effect on those with poor educations. In the economy as a whole, one job in five is held by a college graduate. Only one job in seven lost to trade, however, is lost by people likely to have college degrees.
- Statistics underestimate the disruption caused by expanding trade, since the jobs created by exports are not necessarily in the same companies, or located in the same place, as the jobs lost due to imports.
- Foreign producers able to expand their productivity rapidly may have a significant short-term advantage in crucial areas before wages in their home countries increase to reflect productivity growth. New or infant industries may be hurt by foreign targeting, although with rapid economic change, successful businesses prosper by being perpetual adolescents.
- A productive and innovative domestic economy is essential for national security—particularly in areas where the United States relies on technical advantages rather than on advantages growing out of higher levels of spending or manpower.

The most important tool for improving the U.S. trading position is clearly the restoration of leadership in areas critical to America's export performance, as well as productivity gains in manufacturing. Indeed, manufacturing exports are likely to be the only way that the United States will avoid massive trade deficits in the foreseeable future. But improvements in domestic productivity alone are unlikely to be adequate in a global environment where explicit manipulation of trade by foreign governments is the norm.

To have any positive effect, management of trade must be patient and skillful. Under present circumstances, unilateral steps taken even by the largest economy in the world are unlikely to be effective. Only multinational action is likely to move constructively toward this objective.

U.S. leadership is of vital importance. This leadership can grow only from a coherent strategy built around a clear set of objectives and from skillful and patient negotiations in a variety of international forums. Finding a way to put the U.S. trade and spending accounts in order by shrinking the deficits in government budgets and trade accounts is an essential first step.

The following options deserve consideration:

- Banking and fiscal policies among nations belonging to the Organization for Economic Cooperation and Development (OECD) could be coordinated in fact, not just in rhetoric, to ensure that such policies are not working at cross purposes.
- Policies coordinating international development assistance and trade policy in the OECD could ensure the economic growth in the third world necessary for a long-term solution for their debt problems.
- Domestic policy decisions could be scrutinized more closely for their effects on the U.S. trading position. Prior to the post-war era, trade played such a small role in U.S. business transactions that public choices in critical areas, ranging from telecommunications to banking to agriculture, were made with little attention to the impact of these choices on the competitive position of U.S. firms—or, in the case of telecommunications, to the impact of opening U.S. markets to foreign competition without obtaining reciprocal opportunities for U.S. suppliers to enter foreign markets.
- Cooperative research programs in areas of clear mutual interest could be expanded. There are many areas where the combined world benefit of having a problem solved rapidly is far greater than the short-term gain that any single country could enjoy by reaching the goal first. Breakthroughs in medicine or safety for a variety of

industrial operations would be mutually beneficial.

- Tariffs, rather than non-tariff barriers, could be used when temporary protection is warranted. Tariffs maintain price competition and the value of the higher price paid by consumers remains in the United States, whereas quotas allow benefits of price increases to flow primarily to foreign suppliers—thereby enabling them to further improve their long-term competitive position and expand their markets.
- A variety of programs in export promotion could help businesses unfamiliar with the complex world of international markets find outlets for their products. Many of the Nation's competitors have far more sophisticated systems than the United States in this area. Information alone can help. The Department of Agriculture, for example, has introduced a successful data network that assists comparatively small farming operations in bidding on foreign solicitations.
- Increased language training, translation, and education about the culture of U.S. trading partners could help U.S. exporters understand export markets and more easily penetrate the labyrinth of foreign marketing problems.

People in the Production Recipe (Chs. 10 and 11)

The cycle suggested in figure 1-2 connects people in their role as workers and investors to people in their role as consumers. Some of these people know each other. Some are connected only by passing products to each other, and some are connected through paper flows and electronics. Figure 1-7 provided a crude description of how these networks operated in 1984.

Capital invested in new technology, and the way management chooses to use this technology, has the potential to reshape these relationships in very basic ways. Specifically, information technology has the ability to mechanize tedious and repetitive intellectual tasks in much the same way that farming and manufacturing equipment mechanized tedious and repetitive physical tasks. Many of the jobs being created in the emerging economy do not appear in conventional categories. While the "labor" part of many tasks proves comparatively easy to automate, the part of a job that requires imagination, a capacity for learning, or an ability to work with other people is not easy to automate and therefore represents a growing fraction of all jobs.

The new networks can make the links connecting a person's daily work and a job's contribution to human welfare more transparent. This can mean that an apparel worker operating as a part of a responsive team tailors batches of products for specific clients instead of doing repetitive mass production. It can mean an insurance "para-professional," discussing policies with a customer on the phone and entering data into a terminal rather than keypunching anonymous data. It can mean a teacher having more time to spend with individual students.

Productive use of new technologies will require deep changes in management strategies and job descriptions in areas as diverse as insurance, education, health, and apparel production. These changes in turn can undermine long-standing assumptions about the role of people with different skills, the power commanded by different groups, the role of managers, the factors that motivate work, and the links connecting pay with skill. Some connections can be explained using the economics of "human capital." The networks are obviously also connected by pride, loyalty, prejudice, compassion, whimsy, love, and many other factors not measured by bookkeepers.

For better or for worse, the influence of all these factors is likely to be reshaped as production networks are transformed. The impact is enormously important but impossible to measure. Systems based on one kind of prejudice or irrationality may well be replaced by systems based on others. The task of management is changed when jobs become less precisely defined or when the job definitions themselves are changing. This can mean that the bargaining power workers have achieved on the basis of unique skills will be diminished, and that employers will have difficulty developing satisfactory techniques for measuring individual contributions.

Education is likely to play a central role in determining who is advantaged and disadvantaged by structural change. Education seems important not just for making a person productive as a member of a team with a fixed purpose, but also because it helps people learn and change to keep pace with dynamic production networks.

Since little is known about the merits of different approaches to using much modern production and information equipment, there is little certainty about the kinds of jobs that should be created. Radically different strategies are possible:

- It appears possible to create efficient production networks basing their performance and flexibility on the intellectual and social skills of employees.
- It is also possible to envision a system where a well-educated elite enjoys a majority of the benefits, while the costs of flexibility are paid by workers forced to take temporary jobs with narrowly defined tasks monitored by electronic surveillance.

While it is possible that the second of these alternatives would prove most effective in a highly competitive economy, a wealth of anecdotes suggests that it would not. Choices made in the next few years can play a critical role in shaping the outcome. Policy designed to capture the first of the alternatives must accomplish two things, neither of which is adequate in itself: first, it must ensure an adequate *supply* of well-trained individuals (meaning education available throughout a person's career); and second, it must ensure a productive and innovative economy capable of providing jobs that can take advantage of a skilled work force.

Describing Recent Trends.—While changes in the structure of the economy are changing supplies of new jobs, the entry of the baby boom into the work force, the rapid growth of women in the work force, a move toward early retirement for older men, and a new wave of immigrants have changed the "supply" of skills and experience in the work force. There has also been a change in the racial composition of the work force. An absolute majority of all people joining the work force between 1985 and 2000 will be minorities, many of whom will enter with comparatively poor educations.

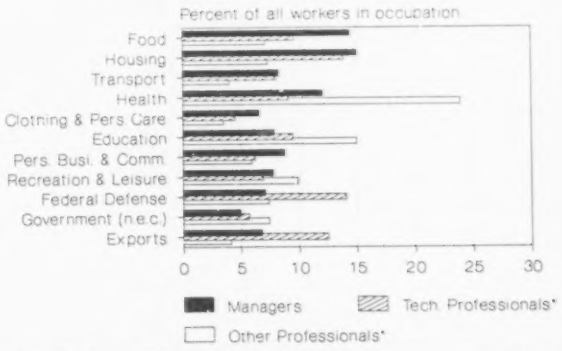
Changes in the role played by transactional, manufacturing, natural resource, and other business sectors translate directly into changes in their share of U.S. employment. The effect is magnified by differences in the rate of growth of labor productivity in each sector.

In part because of the comparatively rapid growth in productivity, the proportion of manufacturing jobs in the economy has declined—from 27 percent of all full-time equivalent employment in 1950 to 18 percent in 1986. Over the same period, jobs in business services and related activities grew from 6 to 15 percent Changing demand and changing regulations were largely responsible for the sharp increase in health care, education, and other government employment during the 1950s and 1960s, and for their relatively unchanged share of national employment since 1975.

Changes in production recipes, and even changes in the overall number of people a firm requires to produce its products, explain only a small part of the radical change in occupations emerging in the economy. Many of the new jobs fall into unfamiliar categories. This is particularly true in areas where information equipment has transformed processes and management strategies. Awkward terms like "para-professional," "para-librarian," and "super clerk" are used to bridge the gap between old paradigms about job categories and ones that remain to be developed. Professions like "teacher" are likely to be transformed into many identifiable specialties in the next few years.

Since figure 1-7 contains all the jobs in America, it is possible to follow the contributions of different jobs to their ultimate contribution in the form of amenity. Figure 1-19 shows, for example, that jobs for natural scientists, engineers, and other technical professionals are heavily concentrated in Defense and Exports. Law-

Figure 1-19.-Where Managers and Professionals Contribute Value*



How To Read This Figure: Nearly 15% of all managers and 9.6% of all technical professionals in the U.S. are employed directly or indirectly in the process of producing Food for domestic markets.

*Not including education and health professionals.

SOURCE: Office of Technology Assessment (see table 10-6 of ch. 10).

yers, social scientists, and other professionals are concentrated in Health, Education, and Recreation.

Looking at the national statistics, managers and professionals were responsible for nearly 40 percent of net jobs added between 1972 and 1986 (see figure 1-20). Undoubtedly, many are doing tasks that would have been handled by clerical personnel in an era where entering and thinking about data could be clearly separated. Jobs in sales, administrative support, and services (other than household or protective services) also increased sharply, while there was a net decline in the number of persons holding jobs as laborers, fabricators, and operatives.

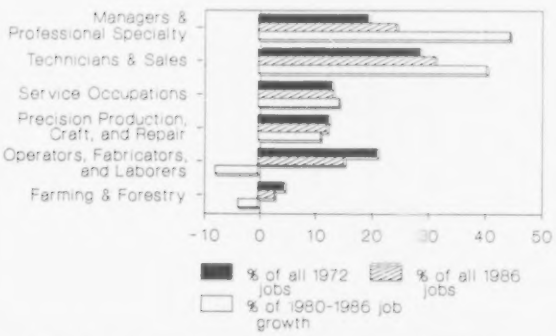
Changes in the scale and scope of firms and establishments that form parts of production networks, and changes in the scale and scope of work teams within individual establishments, obviously reshape the nature of work and the kinds of jobs required. Occupations once part of rigid hierarchies, like mass production manufacturing, may be redefined if productive use of production equipment requires more independent intervention on the part of operators. Attempts to introduce "mass production" management into clerical work have not enjoyed much success. On the other hand, occupations with a tradition of independence (e.g., teachers, home builders, and physicians) may find themselves in more bureaucratic settings.

The changes in occupations are extremely diverse. It appears, however, that on average new jobs are being created most rapidly in areas that require significant amounts of education (see figure 1-21). Growing unemployment rates among young workers with 4 or fewer years of high school was responsible for a significant part of *all* growth in U.S. unemployment rates in the last decade. High correlations between education and income persist, although the connection between skills learned in formal education and skills actually required on the job may be becoming less clear.

There may be a growing gap separating people able to grow and prosper with economic change from people who, for lack of good education or other reasons, remain trapped in positions with little future. Janitors, employees in fast-food emporiums, farm labor, maids, and a variety of other occupations are likely to represent a large part of the American work force for the foreseeable future.

Changes in Pay and Job Quality.—While a review of changes in the kinds of jobs produced provides one measure of how the new production networks have changed the nature of work, it is also important to see how they have changed the quality of

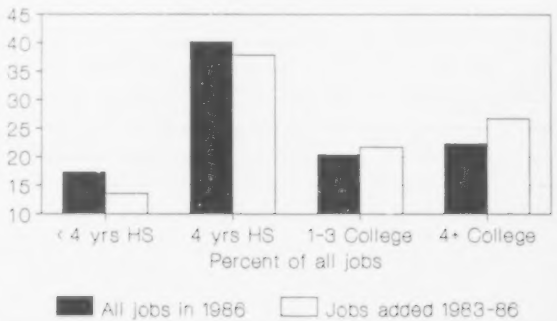
Figure 1-20.-New Jobs and Existing Jobs by Occupation



How To Read This Figure: Managers and Professionals held 19.6 percent of all U.S. jobs in 1972 and 24.5% of all jobs in 1986. About 45% of all job growth between 1980 and 1986, however, resulted from the addition of jobs in these occupations.

SOURCE: Office of Technology Assessment (see table 10-10 of ch. 10).

Figure 1-21.-The Growing Demand for Education (percent of jobs for indicated level of education)



How To Read This Figure: About 22 percent of all jobs in 1986 were held by people with four or more years of college education. Nearly 27% of all new jobs created between 1983 and 1986 were for positions held by people with 4 or more years of college education.

SOURCE: Office of Technology Assessment (see table 11-4 of ch. 11).

the jobs created. Job quality can be measured in a variety of ways: (a) the wages and benefits paid; (b) the equality in allocation of wages and benefits (it is entirely possible for the average wage to grow while the real wage of many employees falls); (c) the extent to which working hours can be adjusted as needed to combine work with raising children, an education, or partial retirement, while maintaining the security of the job; and (d) the extent to which a job provides non-cash rewards in the form of self-fulfillment, pride, and fun. Each of these ways of measuring quality require a different approach.

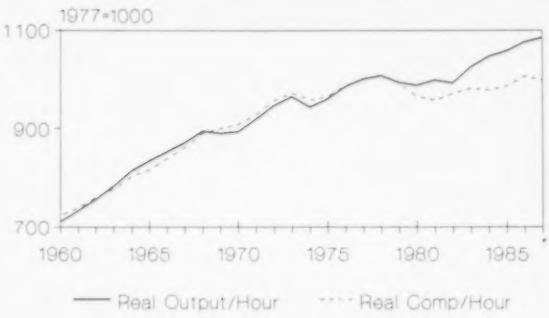
(a) Changes in the *wages and benefits* paid in American jobs are filled with paradoxes. Real hourly wages for non-supervisory production workers have not increased for 15 years while real GNP per capita has grown almost constantly. Employee compensation increased at almost exactly the same rate as productivity until the late 1970s, but comparatively little of productivity growth since the 1970s has been passed to employees in the form of increased compensation (see figure 1-22).

Some of these paradoxes can be explained by the fact that increased international and domestic competition put pressure on U.S. wages. The effect was reinforced by the rapid growth in the work force resulting from the entry of the baby boom. The fall in the fraction of GNP paid as wages and salaries, however, resulted from several other factors. Economic transformation meant that a larger fraction of GNP was needed by businesses replacing equipment. This meant high rates of depreciation and a decline in the fraction of GNP paid as personal income. Non-wage benefits represent a growing fraction of compensation; more personal income was paid in the form of retirement benefits and welfare assistance. Interest, dividends, rents, and other unearned income became a larger fraction of all income.

The many forces at work have made changes in compensation difficult to explain. The industries where compensation increased faster than the average between 1970 and 1985 make a rather curious collection: legal services, the armed services, telephone and telegraph, metal mining, government enterprises (like the Tennessee Valley Authority), motion pictures, health services, and investment companies.

Among other things, new patterns of capital investment have redefined the way wages are paid.

Figure 1-22.-The New Gap Between Growth in Productivity and Compensation (real output & compensation per hour)



How To Read This Figure: Between 1977 and 1987 U.S. productivity increased 8.4 percent but compensation remained nearly unchanged.

*Preliminary.

SOURCE: *Economic Report of the President 1988* (Washington, DC: U.S. Government Printing Office, 1988), p. 300 (see discussion in ch. 11).

Some service industries have invested more money per employee than manufacturing firms since the recession of the early 1980s. Competitive markets, however, mean that these differences are not necessarily linked to wages. High rates of capital investment per worker may actually reduce the skill levels required of workers.

Connections between pay and skill become more ambiguous when the most critical skill offered by an employee may be a capacity to learn new tasks quickly, to perform well in unique situations, and to work well with people. These are "general" skills, rather than "specific" skills that allow workers to benefit from a limited supply.

(b) The factors just discussed, coupled with the shifting pattern of occupations, have reshaped *the way income is distributed*. The wages of men have become somewhat less equally distributed, as have the wages of women. On average, however, the gap separating male and female wages is closing, thereby removing a major source of wage inequality in the work force. The net effect of these changes is that overall wage inequality has not changed significantly. Inequality in compensation has probably grown more rapidly than inequality in wages because the benefits offered for different kinds of jobs differ greatly.

Even if inequality in wages and salaries is not increasing, demographic and other factors are increasing inequality of household income. Growing numbers of households headed by single women, the growing importance of unearned income (which is very unequally distributed), and the fact that high-income people tend to marry each other created a situation where income per household became strikingly less equal during the 1980s.

These and other effects have resulted in a situation where real after-tax income has fallen for more than 90 percent of American households. Some of this has resulted from the decline in family size. Household incomes "per adult-equivalent family member" have increased for most household types.[5] Inequality in household income per family member has, however, also increased during the past decade.

(c) Apart from pay, a worker's ability to *control working hours*, and ultimately the ability to keep a job, is obviously a critical measure of job quality. Two perspectives on this issue are important. Flexibility is important to employees as well as to employers, although for different reasons.

Working parents, students, people in semi-retirement, and people interested in job mobility often find flexibility in working hours an asset. Employers need flexibility to respond to new competitive pressures, business cycles, and to introduce new production schemes. The record on balancing the employer and employee interest in flexibility is mixed.

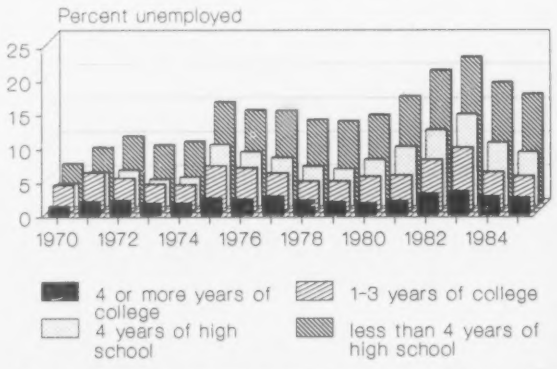
The search for greater flexibility has caused many employers to minimize commitments to permanent staffs. The number of people working in temporary or part-time jobs has increased rapidly. This is an advantage for some and a liability for others. The key question is the extent to which changes in working hours are under a worker's control. Mothers wishing to work at home, independent owner-operators, self-employed construction managers, and farmers are often willing to trade uncertainty for the sense of independence they can achieve by working for themselves or by themselves. For many, however, the uncertainty is highly unwelcome. The number of women who worked part time involuntarily, for example, increased 300 percent between 1967 and 1984.

[5]An adult-equivalent counts children as a fraction of an adult. See ch. 11 for a further discussion.

Surprisingly few people in the United States hold stable, 40 hour a week jobs. Throughout the economy, temporary, part-time, and self-employed workers increased 25 percent between 1975 and 1985 and now represent 27 percent of the work force. High volatility in employment has always been endured by nonunion employees with comparatively few skills. Temporary employment, however, has become common even for individuals with basic skills. Most of the burden of adjustment seems to be born by people with comparatively poor educations (see figure 1-23). College graduates weather recessions with comparatively low rates of unemployment, while unemployment for high school drop-outs went over 20 percent in the early 1980s. Annual turnover rates for blue-collar occupations may be as high as 20 percent.

While there appears to be some growth in the number of firms attempting to stabilize employment by encouraging wage flexibility through profit-sharing and other means, firms have consistently achieved flexibility in the United States through new hires and lay-offs. This is particularly tempting when firms employ older, comparatively expensive workers with obsolescent skills, while new production systems place a premium on credentials and basic skills that these older workers may lack. It is difficult for a firm

Figure 1-23.-Who Bears the Burden of Change? (unemployment and education)



How To Read This Figure: In 1985, 16% of people with less than 4 years of high school were unemployed but only 2.6% of people with four or more years of college were unemployed.

SOURCE: U.S. Department of Education, Center for Education Statistics, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986), table 2-3 (see discussion in ch. 11).

to justify retraining when workers with adequate training are looking for work, and when the costs of training can be lost if an employee leaves a job to work elsewhere.

The shifts in occupation by industry are painfully visible in statistics on experienced workers who lost their jobs between 1981 and 1986 because of plant closings or lay-offs. Of the 5 million people unemployed due to these factors, half had worked in manufacturing, where nearly 1 job in 8 was eliminated. The service industries were virtually untouched. In spite of the severe recession of the early 1980s, only 2 percent of people working in finance, insurance, and real estate, and only 4 percent of the workers in business services, were displaced. These businesses added jobs throughout the 1980s.

Workers displaced by economic restructuring faced a difficult period of adjustment. Of those displaced between 1981 and 1986, less than one-third were reemployed with salaries equal to or greater than their previous jobs. Nearly half failed to find full-time employment. Displacement hit older workers with particular force; less than half of displaced workers over the age of 55 had any kind of employment in 1986.

(d) However important, there is plainly no good index for non-cash rewards of working life. As earlier discussions indicate, there appears to be an enormous range of possibilities in the character of the jobs created by emerging production networks. It is clearly possible that mechanical tasks can be largely eliminated, freeing workers for tasks they find personally more rewarding. It is also possible that they will find jobs more narrowly defined and monitored.

The rapid shift away from jobs in mining, agriculture, and heavy manufacturing has helped create a steady decline in rates of occupational injuries and deaths. Accident rates for manufacturing, for example, are five times higher than those in transactional activities. New jobs, however, present risks that may be difficult to detect. Stress, sometimes induced by job insecurity, may be the most common health problem of high-pressure jobs demanding responsiveness in unusual situations. Rapid changes in production techniques may mean that by the time the health problems of a process are established, the process will be long obsolete.

Strategic Choices.—The challenge of policy designed to influence the way people are used in production recipes is to find a way to encourage supplies of people empowered by their education and experience to assume more attractive positions in the work force, and to encourage employers to build productive systems that create attractive jobs.

A specific challenge is avoiding a potential mismatch between the skills offered by young workers who may have been poorly served by the Nation's educational system, and an economy that increasingly links jobs to education and intellectual skills.

A second goal is to ensure that the costs and benefits of needed business flexibility are equitably shared. Alternatives must be found to flexibility built around lay-offs of people least able to bear the burden.

The following specific programs deserve consideration:

- Encouraging profit-sharing, in which the consequences of poor economic performance of a firm would be shared by employees in an equitable way rather than being, in effect, passed on to those individuals with the least potential for reemployment.
- Establishment of a Learning Research Institute, designed to provide local school systems, universities, and corporate training and retraining programs with an expanded set of tools for increasing the productivity of teaching and learning. The institute would conduct basic and applied research on the use of advanced learning technology, and on the new strategies of pedagogy required to make use of this technology.
- Encouraging, or requiring, universally retainable pensions and health insurance.
- Subsidies for education beyond high school, based on a flexible system of loans and vouchers that could be used to supplement corporate training funds.
- Welfare programs designed to provide incentives for education, training, and reemployment.
- A program designed to ensure that the emergence of flexible production networks often built around comparatively small firms or establishments does not undermine provisions ensuring employee safety, freedom from unnecessary stress, and privacy.

Structural Change in the Eight Major Amenity Networks of the American Economy (Chs. 3, 6, 9, and 12)

The previous discussion focused on a nationwide view of structural change. Many of the most important features of this change, however, cannot be understood without a careful look at the way production networks are being defined to deliver specific amenities. Virtually every production network is either in the midst of a basic change or may be entering one. They share many of the themes already identified: expanded consumer choice and fragmentation of markets, complex production networks, growing involvement in international production, and a profound redefinition of the nature of work. The quality of amenity consumers receive, and the kinds of jobs created to produce this amenity, may change in basic ways. The following section can provide only the most cursory sketch of the complex changes underway in each amenity group.

In some ways the structure of the amenity networks are becoming more similar in the way they are managed, in the quality of the jobs they create, in the way they conduct research, and in the way they are involved in international trade. The unique features of each network, however, merit unique approaches to public policy. Strategies for improving the performance of each network will clearly work best if they are undertaken with a clear grasp of the changes taking place throughout the economy. Similarly, programs designed to improve prospects for growth in the economy as a whole are unlikely to succeed unless they are tested in the way they affect the performance of individual sectors. While the objectives of policy may be read from the following discussion of trends and the potential for change in each major network, no attempt is made to define alternative courses of action.

Food (15 percent of personal and government spending)

The Food amenity can be measured by the quality, variety, and convenience of food products purchased by people in different income groups, and by the extent to which eating habits contribute to good health. The two measures can, of course, give contradictory results.

Better information about the connection between diet and health, changes in taste, and a variety of other factors have reshaped American consumption recipes for Food over the past few years. For example:

- an increased number of working women and more hurried lifestyles have led to growth in restaurant eating, even for breakfast;
- greater concern for health has led to a decline in consumption of red meats and other sources of cholesterol, and to an increase in consumption of fish, poultry, low-fat milk, fruits, and vegetables; and
- there has been an emergence of more varied tastes both in restaurants and stores.

While most Americans enjoy an increasingly varied and healthy diet, poor nutrition continues to be a problem for the elderly, the homeless, poor pregnant women, and other groups.

The network of businesses that bring food to American forks looks increasingly like the networks that bring other retail products to market—similar in the sophistication of their management, in the intensity with which they employ research, in the way manufacturing and business services are integrated into production networks, in the way they are linked to international markets, and in the education and training of the people they employ. Food production remains a major part of the economy, but the productivity of farming has grown so quickly that farming now provides only 3 percent of all jobs. The number of farmers may continue to decline since productivity growth is likely to remain high in most farming activities. There is some concern, however, that inadequate attention has been paid to the problem of increasing efficiency in products other than wheat, corn, and other bulk commodities.

The pizza parable discussed earlier provides some clues about places where productivity growth can be expected. New information technology, improved packaging, and a variety of other technologies can allow a greater variety of fresh products to be available at comparatively low cost. There are some clouds on the horizon. Increases in the scale of firms, from farms to grocery chains, could decrease competition. Foreign firms could continue to capture domestic markets in processed foods and other high-value food products.

The following trends can be identified:

- Consolidation of farm ownership and ownership of food processing and retail operations is likely to continue. By the year 2000, the 14 percent of farms with annual sales of more than $250,000 are likely to be taking 80 to 90 percent of cash receipts. Farms are operated increasingly like businesses in other sectors. The share of managers and professionals in farming has doubled since 1976.
- Net imports of high-value processed foods since 1979 have grown so fast that their value nearly equals the U.S. trade advantage in bulk commodities. Foreign producers are also gaining markets in some food processing technology.
- Grocery stores are getting bigger and offering a greater variety of products. Some stores offer 20,000 products and cover 200,000 square feet. These "superstores" account for 28 percent of all grocery sales. Convenience stores, typically franchise chains, have grown rapidly to fill market needs not met by these super-stores. They are also major financial centers. Supermarkets cash one-third of all non-government checks.
- Restaurants and other food service firms now account for over 5 percent of all U.S. employment. Fast-food, typically in franchises or subsidiaries of large firms, has rapidly gained share. The fast-food format and a variety of technologies like microwaves and deep-fat fryers increased productivity until the mid 1970s, but productivity has not grown significantly since.
- Productivity gains in food manufacturing will continue, but research levels may be inadequate to the challenge. Packaging technology seems particularly critical both to improve quality and to reduce costs—packaging costs more than the contents for a growing number of products ranging from beer to breakfast cereal.

Perhaps most critically, information technologies have the potential to improve the performance and reshape relationships throughout the Food system. Data entered automatically through the scanners that price more than half of all groceries purchased today can improve the productivity of check-out clerks. More importantly, the data entered drives an information system capable of reducing paperwork and improving the efficiency of activities throughout the system. It allows rapid price changes, measurement of consumer response to advertising, closer inventory control, precise dispatch orders for trucking, improved coupon management ($2 billion in coupons were redeemed in 1983) and reduced error rates in billing, ordering, and pricing.

Jobs throughout the Food system are already in flux. Automation is replacing much labor in food preparation and is demanding new sets of skills. Consolidation of wholesale and retail chains, coupled with automated equipment, has eliminated many jobs and has resulted in the substitution of part-time for full-time work. The elimination of skilled jobs in grocery stores (meat-cutting in particular) has reduced employee leverage in bargaining for wages.

In spite of the tradition of independence in American farming, the government is heavily involved in the enterprise. Major Federal programs support prices, regulate international trade, and subsidize research. Farm production commands a significant amount of basic research, a large fraction of which is supported by public funds. The research program has an exceptionally fine record in moving ideas from the laboratory to productive practice.

Government involvement also shapes the geography of Food production. Subsidies for water supplies and price supports have allowed production of commodities like wheat and corn to be profitable in parts of the country that might not otherwise support such production.

Health (11 percent of personal and government spending)

Consumption recipes for good health involve increasingly complex decisions about investments in health promotion (e.g., appropriate exercise), disease prevention (e.g., changing smoking and drinking habits, controlling hypertension), public and private investments in environmental controls and safety devices, and investments in clinical treatment of medical problems. In 1983, approximately $350 billion was paid to health enterprises; $17 billion was spent for self-care medication, fitness equipment, and nutrition aids; and $50 billion for environmental controls.

It seems possible to improve national health status without significant increases in spending given

a way that provides a better match between spending and amenity measured in terms of improved health and longevity. Calculations presented in chapter 3 show that average life expectancy in the United States could well reach 80 years without extraordinary breakthroughs in medical technology. This would almost require greater incentives for individuals and households to take responsibility for their own health. Smoking habits, seat belt use, modest attention to diet, prenatal care, the strength of a person's social contacts, and other aspects of lifestyle have a major effect on life expectancy. Improved health would also require strong incentives for research, development, and innovation.

It is also possible to imagine a system choking on regulations and red tape, a system bureaucratized to the point where patient care was compromised in the interest of avoiding litigation or following rigid guidelines. Pressure to reduce health care costs when an aging population needs more health care services could lead to a real decline in health status and increasing inequality among different segments of the population.

It proves difficult to draw a clear line between consumption and production recipes for Health. It is clear that both are changing. A better understanding of the connections between diet, smoking, and other aspects of lifestyle and good health seems to have altered many American habits. The high cost and sophistication of medical technology have made management, research, productivity, paperwork, litigation, finance, and even advertising an important part of a business once dominated by independent private practitioners. These new tasks, coupled with new alternatives for women once willing to work at low wages as nurses, are reshaping the nature of work in Health professions.

New technology, better consumer information, and improved management of health resources have improved the health status of Americans during the past few decades. Life expectancy in the United States has increased 6.5 years since 1950 (the penalty for living longer is that each person spends more time in some state of ill health).

These averages belie great inequalities. Life expectancy in Hawaii is higher than in Sweden or Japan, while life expectancy in Louisiana is lower than in Singapore. Infant mortality rates in Washington, DC are close to those of the poorest developing countries. The differences are due partly to inadequate access to health care, and partly to the fact that differences in lifestyles contribute to differences in health. The comparatively poor U.S. health statistics occur in spite of the high quality of U.S. medicine because of defects in other parts of the American recipe for Health. The health status of the poor is often limited by a variety of social and environmental conditions beyond the reach of traditional health-related spending. A large number of households are not covered by any health insurance program, public or private. This group may grow as the work force turns to greater use of temporary and part-time workers. These people tend to be much sicker by the time they enter the health care system. American mortality statistics are, therefore, not necessarily a good measure of the quality of the U.S. medical facilities. They may instead be a measure of the availability of insurance coverage, inequality in income, racial discrimination, and other social phenomena beyond the reach of medical enterprises.

Technology has obviously made a significant contribution to the quality of American health care. Surgical techniques continue to improve. Biotechnologies promise both new diagnostics and, hopefully, new treatments for a variety of conditions. Engineering advances permit prosthetics, artificial organs, and greater assistance for the visually and hearing handicapped.

Expensive new technologies like Magnetic Resonance Imagery and Computer Assisted Tomography have centralized some activities into "tertiary" hospital centers. Other technologies have permitted treatments once requiring extensive hospitalization to be conducted in smaller clinics or on an "outpatient" basis, and have permitted home treatment to replace some hospital care. Implantable pumps, for example, allow controlled dosage of a variety of drugs outside of hospital settings.

Information equipment may affect health care costs, health care quality, and the structure of Health businesses as profoundly as any of the technologies just listed. More sophisticated management systems, growing complexity of procedures, and an avalanche of paperwork connected with cost-containment and (increasingly) legal issues have made information management a major part of the health care busi-

ness. Computer-based record management has improved efficiency and reduced costs in everything from patient billing to inventory control. It is now possible to store high-resolution photographs of specimens and other records electronically. Information equipment permits small home care firms to manage complex paperwork. New technology can permit rapid communication between specialists in different parts of a city, or indeed different parts of the country. It can permit telemetry to monitor patients being treated at home.

The challenge of better integration of health treatment can be seen in the baffling statistics on use of different therapeutic techniques. The probability that a women will have a hysterectomy, for example, is 20 percent in some markets and 70 percent in others. At least one (possibly both) of these regional practices must be wrong. Information equipment should be able to permit more precise sharing and analysis of procedures. In some cases, information equipment can even provide a "second opinion" for a physician otherwise forced to rely on his or her own memory about techniques.

The effects of these and other changes have already transformed the structure of "production" in health enterprises. Once dominated by general practitioners who would occasionally refer a patient to a hospital, the business of medicine now integrates individual practitioners, group practices, and tightly managed hospital corporations, as well as a growing array of satellite institutions: testing laboratories, out-patient clinics, hospices, nursing homes, home-care specialists, and even "doc in a box" emergency care facilities in shopping centers. The number of people receiving medical care from a health maintenance organization (HMO), as opposed to a privately practicing physician, nearly doubled from 1981 to 1985. Using modern management techniques, hospitals and other health organizations are beginning to behave like other service organizations. Enormous investments in environmental protection have created wholly new business opportunities. Cleaning hazardous waste sites alone promises to generate a significant amount of future business.

The changes just discussed are also transforming the nature of health as a profession. Physicians are frequently hired on fixed salaries much as any other technical professional. A shortage of nurses is developing as women realize that other occupations result in greater returns for equivalent levels of experience and education, and typically offer less erratic hours.

The cost of new technology, coupled with rapid growth of the elderly population and expanded public insurance programs, have also led to explosive growth in health care costs and have spawned a number of regulatory remedies to control costs. While it may well be that Americans would freely choose to spend an increasing share of their incomes on Health, the question of whether spending levels are or are not appropriate cannot be resolved by a simple appeal to market forces. The task of designing a financing system that provides incentives to maximize the quality of health outcomes while minimizing costs has proved to be vexing for both public and private insurance programs.

By the early 1980s, there was general agreement that the incentive and regulatory systems in the health industry needed revision. Both private and public insurers moved away from "fee for service" reimbursement. The challenge has been to find a substitute that does not collapse under ever more invasive regulation. Government and private insurance regulations have attempted to force greater attention to the costs and benefits of different treatments. As a result there has been some reduction in patient use of hospitals and physicians. Hospitalization rates for prepaid plans, where hospitals have a strong incentive to minimize costs, are 10 to 40 percent lower than those for people with insurance that pay fees for services. Physician visits per person have fallen since 1976.

Housing (20 percent of personal and government spending)

Owning a detached home remains a firm part of nearly every American's vision of a good life. Decent housing is largely a matter of taste, but it surely includes security, a pleasant landscape, low maintenance, and low operating costs. It also means a pleasant home with access to jobs (frequently jobs for several members of the household), shopping, schools, and day care facilities.

Changes in taste and demographics also redefine definitions of housing quality. The rapid growth of the elderly population, for example, creates new

housing needs. Fully 40 percent of Americans aged 65 to 74 have some kind of disability that limits their activity, and 63 percent of those over 75 have some disability. Shrinking leisure time has made the amenities of a comfortable home substitute for other forms of recreational spending. Homes have also become centers for home health care, and even places of part-time work.

Housing is, of course, an investment in addition to an amenity. Home ownership differentiates those with assets from those that lack them in contemporary America. The net worth of households owning homes is nine times higher than the net worth of renters and home equity represents two-thirds of the net worth of home owners. The high mobility of Americans reinforces the tendency to consider a home a temporary investment, with purchasers paying as much attention to the hypothetical desires of the next buyer as to their own.

On average, the quality of American housing is improving. The average home has more rooms per person, and is more likely to have air-conditioning, a full garage, and a well-equipped kitchen, than ever before. On the other hand, home ownership has moved beyond the means of many young Americans, particularly those moving to areas where employment is expanding rapidly. The fraction of median household income needed to purchase a new home is more than 50 percent above what it was in 1968. Housing costs are also an increasing burden for poor families, particularly homes with a single wage earner. The cost of buying the average new house would require 75 percent of the average income of single women. One result of these trends has been an increase in renting. The extreme symptom is growing homelessness.

Many households have found affordable housing only at considerable distances from their jobs—a major problem for households with two earners. In effect, housing costs are traded against the cost of time spent commuting. Only half of the people in the San Francisco area now work and live in the same town. Since men commute 35 percent more miles and spend 15 percent more time commuting than women, it appears that women may be taking jobs closer to home, possibly sacrificing income in order to combine lives as a homemaker and paid employee.

The high cost of housing results from several factors:

- Land costs have soared, particularly in rapidly growing urban areas. Growth constraints have exaggerated the problem in many areas.
- Changes in regulations have forced purchasers of home mortgages into competition with wider financial markets. Financing expenses remain a dominant housing cost.
- Productivity has fallen in construction.
- Rising energy prices have increased the price of home operations.

The costs associated with land prices are obviously not touched by changes in the production recipe just described. They require changes in the efficiency of transportation, changes in tax laws that may encourage speculation, and policies that may affect the location of jobs, retail facilities, recreational facilities, and other destinations.

The recipe by which houses are produced has not changed significantly in some time. In spite of forecasts about factory-built housing dating to the early 1930s, little has actually happened. Radical swings in demand for new housing, and a history of fragmentation in home construction businesses, has kept research and capital investment in this industry far below that of most manufacturing firms. There are reasons to believe, however, that significant change is not only possible but necessary.

The U.S. housing industry could follow the trends of the industry in Sweden and Japan, moving construction away from highly fragmented small firms with few investments in capital equipment or trained employees, and toward production networks that more closely resemble other manufacturing operations. The result would be a profound change in the nature of the institutions supplying Housing in the United States, as well as a change in the quality of the product:

- The house itself could be designed on the basis of more systematic research. At present, most innovations come from component suppliers, with little research directed at the integrated performance of the structure itself. There is compelling evidence that simple, inexpensive changes in home design make new homes not only more

comfortable but less expensive to operate.

- Factory construction could lead to both greater reliability and energy efficiency. Houses could be "brand name" products with multi-year guarantees of reliability.
- Productivity of home manufacturing could benefit from greater capital investment in production facilities and the use of advanced assembly techniques. The home building industry invests little in improving production technology.
- Homes could be assembled by firms specializing in site preparation and rapid site assembly of factory components. These firms could either be independent or franchises of larger firms (as they are in Sweden).
- Homes could be marketed from showrooms, where prospective clients can design floor plans and explore alternative exterior and interior finishings on computer screens. The Japanese claim to be able to convert designs into finished houses in 3 weeks.

Changes of the sort just described could radically change the nature of construction work. The construction industry has always achieved a high degree of flexibility by using temporary work teams. It has an extraordinary ability to assemble many disciplines quickly. Changes in production recipe could make construction work more closely resemble jobs in other manufacturing industries. (Of course, it is also likely that manufacturing enterprises will change in ways that may make them more closely resemble construction in the way work teams are assembled on short notice.)

If the construction industry began to resemble the organizational structure of manufacturing, a large number of design, research, and customer support jobs would be created. Sales operations would combine design, finance, and marketing. Production work would involve programming equipment to produce unique products, maintaining sophisticated equipment, and learning to operate new tools.

The changes in construction networks could, however, also be used to replace skilled construction jobs with low-paid, low-skilled employees in production facilities. Many "factory" construction facilities in the United States use temporary labor.

The U.S. home building industry has largely been shielded from foreign competition but the situation has changed rapidly. Foreign appliances, fittings, and other components are entering U.S. markets rapidly. There is a real risk that without some significant change in the productivity of U.S. construction techniques, U.S. firms could become little more than assemblers of foreign products using foreign-made tools.

Without some change in housing technology or policy, a growing number of Americans may find themselves faced with painful choices between cramped quarters and long commutes. It is possible that productivity would continue to decline, and U.S. home owners may be burdened with continuing increases in home prices, and with inefficient structures in which operating costs could rise sharply if energy prices increase.

Since residences consume nearly 30 percent of all electricity generated by U.S. utilities, and are largely responsible for the peak demands that motivate new plant construction, there is a critical need to communicate accurate costs to residential customers. Residences also consume approximately 20 percent of U.S. oil and gas. It should be possible to cut energy consumption of new homes in half with improved windows, lighting, appliances, better heating and air-conditioning controls, and advanced materials. Moreover, communications technologies are being tested that can help households adjust electricity use to minimize cost both for themselves and the utilities. This will require pricing electricity not as a commodity but as a product whose value depends on the season and the time of day.

Transportation (11 percent of personal and government spending)

The amenity of Transportation is measurable by the extent to which people can go where they want, when they want. This has become almost synonymous with travel by automobile; 86 percent of all work trips in cars were made alone in 1983, and the driver was alone in a car for 60 percent of all vehicle miles traveled. In spite of massive public investments, travel on public transit continues to decline. The comparatively low densities of most U.S. living and working areas makes transit a poor alternative for all but the most densely populated urban centers, such as New York, Chicago, Boston, or Philadelphia. Mass transit is often used only as a last resort. One-third of mass transit passengers live in

households that do not own cars. The central challenge of personal transport in the United States remains one of preserving the amenity inherent in a personal vehicle while providing needed mobility for those unable to drive.

Complex networks of production have altered demand for business transportation services (typically demanding more reliable and timely deliveries), and have changed the geography of production and the location of jobs. Demographic changes and changes in housing costs have shifted the location of housing. The result is new patterns of demand for both personal and business transportation.

In 1980, 60 percent of the 31 million commuters in the Nation's 25 largest urban areas lived in suburban areas and traveled to jobs outside the central business district. There is now one car for every licensed driver. Public transport is increasingly dominated by air travel, which has appeared as a substitute for long bus and train trips.

There has been little net improvement in the real efficiency of auto travel. The real costs of driving a mile have not changed significantly in 15 years. Imports of inexpensive and durable cars increased competition for domestic markets and placed new emphasis on quality and fuel economy. These improvements have largely offset the higher cost of fuel. On the other hand, travel times to work and shopping remain comparatively unchanged because of a combination of congestion and decentralization. Little can or will change without both private efforts to improve personal vehicles and a public effort to provide improved highways. The recipe for Transportation plainly involves a coordination of public and private investment.

Transportation provides an enormous variety of jobs, ranging from high-skill/high-wage positions for airline pilots to minimum wage jobs in gasoline stations. Since personal transportation is by private automobile, Transportation provides as many jobs in manufacturing as it does for paid vehicle operators.

It should be possible to make the Nation's Transportation system faster, more flexible, less costly, and safer by increasing the variety and capabilities of personal vehicles. High-performance, two-passenger vehicles could be given privileged commuter lanes and parking. Low-speed vehicles with minimal licensing requirements could provide mobility for the elderly or young teenagers in communities. Improvements are also possible in the coordination of traffic signals, and better information on congestion and road conditions can be transmitted to individual vehicles—again, a combination of private and public equipment.

Improved communication systems may permit more people to work at home, but it appears unlikely that this will significantly reduce transport needs. On the contrary, communications technology may increase travel, by making more people aware of opportunities for business, shopping, and recreation. Cellular telephones can even make cars double as offices.

The near doubling of fuel economy of automobiles played a major role in reducing U.S. and world petroleum imports. It is possible to achieve another doubling or even tripling in fuel economy without significant sacrifices in vehicle performance. A coordinated movement to a fuel other than gasoline would also ease pressure on the system. This, too, is likely to require public as well as private investment if such a transition is to occur before a crisis strikes.

Without some imagination to break the current stagnation in the performance of the personal transportation system, it is possible to imagine a system that not only fails to improve but that offers declining levels of amenity. The system could become increasingly congested and poorly matched to the diverse needs of a complex society. It could also fail to serve the needs of production systems dependent on fast, reliable, flexible transport systems. Without adequate investment, the existing Transportation infrastructure could deteriorate, and congestion along existing highways could increase. A system heavily dependent on oil could be very vulnerable to the availability and price of foreign oil.

Clothing and Personal Care (7 percent of personal and government spending)

Americans are clearly impressed by the symbolism of clothing, and clothing purchases rise sharply with income. Americans consume twice as many square yards of cloth per person as the average French or German consumer.

The technology of production in textiles and apparel is going through revolutionary changes. Computer-driven shuttleless looms and cutting machines now dominate the market. Apparel assembly, which the industrial revolution seems to have bypassed, may soon be automated using robotic sewing equipment now entering the market.

Perhaps more importantly, the network connecting producers together appears to be on the brink of a major change. The change is forced both by new technology and the pressure of imported products that have devastated markets for domestic producers in a growing number of products. The industry is moving quickly to integrate operations from fiber production to retail outlets. The goal is to make a radical reduction in the 65 weeks now required to move fiber to a retail store in the form of finished apparel. This is done through adoption of standardization, responsive transportation systems, and production equipment that allows high productivity in comparatively small batch production. These responsive systems allow retail outlets to carry more products in more sizes without increasing inventories. The cost of producing products tailored to a person's unique measurements may soon be little more than the cost of mass-produced garments. If this occurs, the industry will have come full circle from tailoring to commodities and back to tailoring in a hundred years. Ironically, the productivity of individual steps in this network (e.g., trucking or weaving) may decrease while the productivity of the system taken as a whole may increase.

Given the intense nature of foreign competition, it seems apparent that the network delivering apparel to U.S. consumers will either have to undergo major improvements in productivity or become little more than a vendor for foreign products. On the other hand, it is entirely possible that a flexible and responsive domestic system can provide customers with fashions and service impossible to provide from foreign suppliers.

Whether reshaped by trade or by new technology and management systems, employment in the collection of enterprises just described will change. The trend is already evident. Between 1977 and the end of 1987, employment in the apparel industry fell 16 percent and textile employment fell 18 percent. Heavy investment in modern production equipment has eliminated many jobs in fiber production and textiles. Automation will also reduce jobs in apparel assembly. The jobs eliminated will largely be those held by people with comparatively low skills. Many of them are minorities with few resources for other jobs. The jobs created will require skill in managing orders, maintaining and programming sophisticated equipment, and other functions likely to require a significant amount of specialized training. Some effort will be needed to provide people now employed by the industry with the new skills needed.

Job loss in textile and apparel production is partly offset by rapid growth in apparel retailing. Retail apparel and accessory stores provide jobs for nearly 1 million people, and over 2 million people are employed by department stores.

In spite of the importance of this sector of the economy, the U.S. Government spends few resources on research and development work for textile or apparel technology.

Education (7 percent of personal and government spending)

Education is both an end and a means to an end. It provides tools critical for finding rewarding employment in a complex economy. Education also proves to be strongly correlated with health, and with an ability to recover from such personal disasters as illness, divorce, or a job loss. It opens doors to cultural opportunities that are otherwise inaccessible.

Education is also one of the Nation's largest enterprises. Between $300 and $500 billion are spent on Education each year (the range results from an inability to count corporate investments in Education). The total investment in learning exceeds the $240 billion annual private investment in buildings and structures. About one American in three is enrolled in some kind of educational program during the year.

The Nation's educational system may be on the brink of a major change. This results both from a fundamental change in the demand for educational services and from the fact that new technology makes it possible to consider real improvements in the productivity of both teaching and learning. Taken together, these forces could change what is taught, when it is taught, where it is taught, and the nature

of teaching as a profession. There are some stark alternatives:

- The system could change in a way that makes learning more productive and fun while allowing teachers more time to spend with individuals as coaches or tutors. It could put more power in the hands of the learner, tailor instruction to each person's level of understanding and learning speed and technique, and make it easier for an individual to learn when instruction is most needed.
- The system could create rigid centralization of course design, mechanical and impersonal instruction, national regulation, and a contraction of choice for both students and instructors. Adult training programs could widen the gap between those with good educational skills and those lacking them.

The difference between the two depends heavily on public choice.

Demand for Education has changed both in qualitative and quantitative terms. Demand for formal educational services (K-12 and college education) declined with the graduation of the baby boom generation, while demand for adult training has increased. Not only do the emerging jobs require a higher level of educational skills, but jobs are changing in ways that require a continuous renewal of skills. The kinds of basic skills required of entry-level employees are reshaped by these new demands. Skills in working with people in groups, in self-education, in coping with ambiguity, and in coping with too much or too little information become requirements as important as any specialized training.

The real costs of employee training are almost impossible to measure. Formal training can be tracked, but the costs of informal training and of problems created by inadequate training (e.g., Three Mile Island) are more ambiguous. They are obviously very large. It appears, however, that people most likely to benefit from formal and informal on-the-job training are those who come to the position with a good basic education. If anything, retraining appears to be widening, not reducing, the gap separating highly skilled from unskilled employees.

The basic characteristics of America's educational system have not changed significantly in a century, and each student continues to have unique learning styles and interests. The existing educational system appears to be highly personal and differentiated. However, the isolation of individual instructors may have the opposite effect. Studies indicate that a typical student in primary or secondary school (grades K-12) receives less than 1 minute per day of individual attention. Teachers throughout the country teach nearly the same course from similar texts, and spend large fractions of their time repeating standard lectures or performing routine administrative functions. Apart from buildings, desks, and blackboards, virtually no capital equipment is used in this, the Nation's largest information enterprise. Television has not proved to be a major asset.

Over the next two decades, capital equipment could improve the productivity of Education at all levels given adequate research and capital investment. New information technologies allow active response to students not possible with television—a critical distinction. Existing "computer-based instruction" systems are often disappointing, primarily because of the limitations of existing software. But there is reason for considerable optimism.

Artificial intelligence techniques could help diagnose defects in what a student understands, while less exotic software could help with needed drill and practice. Simulations that use images, sounds, and text can lend realism, and can remove the barriers of abstraction that so often impose themselves between formal education and practical mastery of a subject. Indeed, since the working life of many graduates will increasingly be spent viewing reality through computer screens—whether they are operating nuclear powerplants or analyzing a commercial insurance policy—the distinction between simulation and reality can be extremely small. Communication systems could forge links between teachers working in similar areas, permitting specialization not possible in comparatively small schools. They could also allow students to work more easily with each other, and could help tie homework to school work.

Significant changes are likely in the nature of teaching as a profession even if technology is not widely introduced. There are new demands for instructional quality and efficiency. At the same time, women who might once have entered teaching be-

cause they had no other professional opportunities are now being drawn into a variety of other occupations. Introduction of more capital equipment and expansion of teaching beyond traditional school settings will lead to much greater differentiation in an occupation now called "teachers." Tasks involving software development, equipment maintenance, holding tutorials, working with students around the country in a highly specialized area, identifying learning pathology, and a range of other areas will lead to jobs for a variety of specialists, and doubtlessly a variety of pay scales.

Firms ranging from insurance underwriters to producers of metal parts have found that the potential efficiency gains from new information technology cannot be captured without a profound change in management strategies. Education will be no different. Management reforms are, however, notoriously difficult in Education because of the sector's fragmented nature. Hundreds of State and local governments manage K-12 instruction. This has a healthy effect by allowing teachers considerable power in resisting grand schemes unlikely to further instruction. In some cases, however, the extreme fragmentation can frustrate progress. Corporations and the Armed Forces have moved most rapidly to exploit the advantages of new instructional technology. This is due in part to a different style of management, and in part to the fact that since these organizations pay salaries of both students and teachers, they are as interested in the productivity of a student's time as the productivity of the teacher's time.

As in many other sectors examined here, making full use of the potential of emerging technology requires a major investment in research. At present there is no national center for focusing research on education equivalent to the National Institutes of Health or the Agricultural Research Center. By far the bulk of research on educational technology supported by the Federal Government is undertaken by the Department of Defense. While a private information company typically spends several percent of gross revenue on research, virtually nothing is allocated for research directed at the real problems of teaching and learning. If the fraction of gross expenditures invested in research were the same for Education as for the average privately owned business in the United States, about $9 billion a year would be spent for Education research. This is 60 to 90 times more than the present allocation.

Personal Business and Communication (6 percent of personal and government spending)

Astonishingly little is known about the volume or the function of information entering or leaving U.S. homes. By far the greatest volume of information is broadcast to homes through television, radio, and direct mail. Large amounts of information enter through selective purchases or rentals of video tapes, magazines, books, newspapers, and cable television. Two-way "point-to-point" communication, involving telephone conversations and correspondence, is responsible for a comparatively small fraction of the volume of information, though this activity traditionally receives much more attention.

Most of this information is used for entertainment. The economics of information are curious, since much of it is subsidized by advertisers. Advertising pays for nearly all broadcast costs, and 50 to 75 percent of the cost of newspapers and magazines. The costs paid by individual consumers come entirely in what they pay for receivers, and in the time spent watching advertising messages.

Apart from entertainment, information is used largely for personal business—primarily for retail purchasing, but also for financial transactions and bill paying. Keeping in touch with friends and even gossiping represent other critical markets.

Direct marketing has enjoyed an expanded business, using television and direct mail to communicate from businesses to homes, as well as 800-number telephone systems and credit cards to communicate from homes to businesses. In the future, some of this electronic shopping will certainly become part of computer-based systems. One key barrier to computer-based systems is the lack of serendipity: when people enter files looking for something in particular, spontaneous response to products is not possible. Cable television has introduced a novel way to bypass this problem, by holding what amounts to a continuous sale where proprietors take telephone orders for products shown.

How should amenity be measured in this case? By analogy to Transportation, improvements in in-

formation resources depend on a person's ability to get the information he wants when he wants it (leaving a little room for serendipity). It seems that this system is moving rapidly toward one with greater consumer choice, more control over the information that enters the home, and more direct payments for services actually used. VCRs, cable television, and the explosion of specialized magazines have all allowed special tastes to flourish where broadcast television and general interest magazines once dominated markets. Similarly, the once undifferentiated telephone has been replaced by a variety of specialized products, ranging from $6 disposable phones to ports of entry into sophisticated data management services. Advanced communications to homes can also mean more control over electricity bills, better home health care services, and greater opportunities for education, while cellular communications can extend such freedoms to private vehicles. Many more services are likely to be available as the struggle over regulation of telephone services is resolved.

The deregulation of banking, coupled with sharp increases in the incomes of many households, has generated a boom in individualized financial services. A growing fraction of all households use tax accountants and financial advisors to provide specialized services. Few now buy "whole life" policies that combine savings with insurance.

While deregulation has spawned an explosion of competition, it has not had the effect of creating much real diversity in most markets. AT&T, for example, retains 90 percent of the long-distance market. Local telephone companies maintain regulated monopoly control over local telephone services, and are gradually being allowed to compete with other firms for lucrative advanced communications services. There is a possibility that these firms could expand on their regulated business to become regional monopolists in a variety of unregulated areas.

The businesses in this group provide jobs dominated by clerical and information management occupations. The complex pattern of change possible in these occupations has already been discussed. In some cases, modern communication equipment has fragmented jobs into narrow functions that can be carefully monitored by electronic means. This has been true for telephone operators or clerks working on routine insurance accounts. In others, clerical tasks have been upgraded and combined with quasi-managerial tasks. This is particularly the case when products cannot be handled using mass production techniques (e.g., commercial insurance). Between 1983 and 1986, employment growth in clerical and other administrative support personnel slowed in finance, insurance, and real estate businesses, while jobs for people classified as managers, professionals, and sales workers increased rapidly. There is much uncertainty about the future of employment in these occupations, and much room for choice.

Recreation and Leisure (9 percent of personal and government spending)

Of all the sectors examined in this analysis, the amenity of Recreation and Leisure is most difficult to measure objectively or even define precisely. How can the recreational value of dining be separated from biological necessity? How much of a purchase of a home or a car can be considered recreational? Obviously, both time and money are critical when considering this amenity.

Free time available to Americans has been shrinking for at least a decade and, as a result, spending for Recreation and Leisure has typically become more intense (more spending per unit of time but less time). Moreover, Americans earn far fewer vacation days than their counterparts in Europe. U.S. manufacturing employees averaged 29 days of paid vacation and holidays in 1982, while the West Germans took 41 days and the French 35.

Outdoor recreation and travel command a firm share of U.S. leisure time in spite of advances in home electronics. In fact, home electronics may have expanded interest in travel and in a greater variety of away-from-home activities. Time constraints remain a bigger problem than money for many families. Vacations tend to be short and intense, and many households now look for short trips close to home in lieu of the traditional "two weeks at the beach" vacation. There is little sign that national tastes in recreation are becoming more homogeneous. Business is booming for everything from theme parks to National Barbecue cooking contests to Mississippi Catfish Festivals. Hotels and motels cater to specific client groups, such as older couples or families with children.

In the future, technical capabilities of home electronics should continue to expand quickly. Investments in home capital equipment now include video equipment (where high-definition TV can greatly improve picture and sound quality) and sophisticated audio equipment (digital disks and tapes offer remarkable improvements). New information technologies also promise to expand opportunities for travel. Airlines were among the first to use sophisticated national reservation systems. Travel agencies (an industry that has been growing rapidly in recent years) offer growing variety of information services. Reservation services can be provided for hotels and motels, automobile rentals, sports and theater events, and a variety of other activities. Some agencies are introducing expert systems to help match unique interests to travel reservations. In the near future, reservation systems will permit a video tour of prospective destinations, hotels, and even individual rooms. Prototypes are already in place.

It should be possible to enrich opportunities for using leisure time through the use of advanced technologies, which can bring a greater variety of entertainment, education, and shopping services to individual households and improve access to recreation and entertainment facilities away from home. On the other hand, recreation and entertainment opportunities could be curtailed for all but the affluent, given a decline in advertiser-supported TV and newspapers or a decline in public support for parks, town centers (as opposed to privately managed shopping malls), and cultural facilities and activities.

Many outdoor recreation activities involve an integration of publicly supported infrastructures, such as parks, beaches, civic centers, and sports stadiums, and private investment, such as hotels, travel agencies, and theme parks. Many businesses depend on public investment in these infrastructures, and on public efforts to maintain the quality of the environment in parks and other recreation areas. There may also be a role for public information services such as the city of Baltimore, Maryland's INFOTOUCH.

Not counting jobs in transportation services or jobs in restaurants, the Recreation and Leisure industries are responsible for 8 percent of American jobs. Many, like those for hotel employees or employees in theme parks, are comparatively low paid and are in occupations where productivity increases are difficult to envision. In fact, hotels appear to be becoming more, and not less, labor-intensive. On the other hand, the production and distribution of consumer electronics and the software used on these systems can create many rewarding jobs. American production of many consumer electronics products has all but disappeared in the face of foreign production. Foreign producers have used their command of manufacturing the current generation of consumer electronics products to fund the development of a continuing series of innovations. U.S. firms will need to move aggressively to recapture these promising new markets.

Pulling the Pieces Together (Ch. 13)

The kinds of change discussed so far will have far-reaching effects on the future of the U.S. economy. Unfortunately, none of these effects can be confidently forecast because virtually none depends on immutable natural forces. On the contrary, the Nation's economic future depends as never before on choices made by households, producers, workers, and the government. These choices will, of course, also be shaped by the regulations and incentives the government oversees, and by the skill with which the government manages international affairs.

Forecasts where so much depends on choice are absurd. What can be done, however, is to sketch out self-consistent descriptions of the different kinds of economic structure that *could* emerge in the United States during the next two decades. The implications of public and private choices become clearer when displayed in this way.

Four scenarios are used in this report to explore the implications of alternative futures for the U.S. economy. These postulate:

1. continuation of present trends,
2. a recovery of the manufacturing sector,
3. a stagnating economy, and
4. a transformed economy making optimum use of new technology.

The results range from cases where GNP grows slowly (1.5 percent per year) and unemployment reaches 23 percent (measured in conventional terms) to one where GNP grows rapidly (3 percent per year) with possible labor shortages. While there seems to

be no question that the second case is preferred, this quick judgment should perhaps be suspended while some of the fine print is examined. A case could be made that GNP growth does not necessarily provide a good guide to progress. Indeed, the scenarios reveal that the choices made by consumers can greatly affect the level of amenity they achieve, particularly in areas such as Health, mobility, and Housing, even if their incomes do not rise. Improved amenity achieved with a working week of 35 hours (which would drastically reduce unemployment) may look better than 3 percent GNP growth that fails to raise living standards equitably. With careful management, however, it should be possible to have both rapid growth *and* improved amenity.

Changes in personal and government consumption recipes, and in income distribution, have a surprisingly small impact on the economy in terms of the share of value-added or jobs in manufacturing or other sectors—although individual enterprises would obviously be affected much more strongly.

The different scenarios also reveal interesting information about the future of natural resources and energy consumption. Changes in household and government spending recipes can have a significant impact on national use of energy. The combination of greater attention to energy efficiency by consumers, and production recipes that demand less energy and material inputs, can lead to a significant decline in national use of resources. Optimal use of new technology could result in a 40 to 60 percent *decline* in use of natural resources, even when there is rapid (3 percent) economic growth.

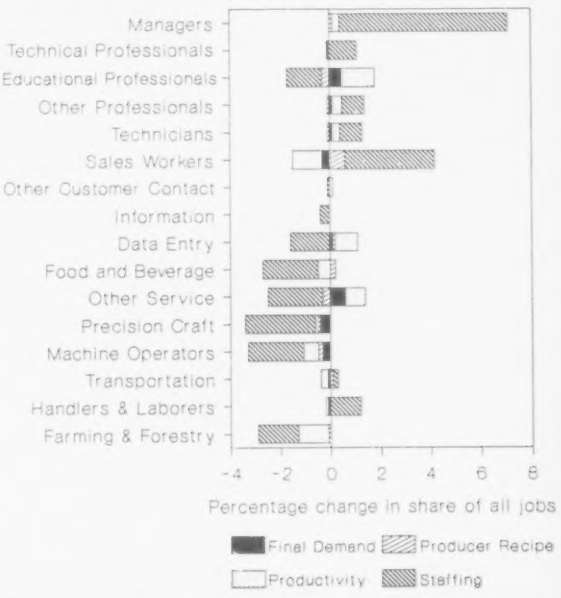
Since air and water pollution, and the generation of hazardous waste, scale roughly with demand for energy and material resources, these differences obviously translate into large differences in future environmental quality. The scenarios thus demonstrate that it is possible to have vigorous economic growth while reducing demands on the natural environment. Indeed, most innovative production schemes result in a decline in environmental releases simply because most new technologies are intrinsically more efficient.

The impact of trade depends both on whether trade volume continues to grow as a fraction of GNP (in constant dollars) and on the nature of U.S. exports and imports. High levels of trade can lead to a net increase in employment since in many cases the number of jobs generated per dollar of exports exceeds the number of jobs lost per dollar of imports. Employment in manufacturing and agriculture is particularly vulnerable to different patterns of trade.

Changes in production recipes, and assumptions about productivity in each industry, have the largest effect on the *industries* likely to produce jobs in the future. Changes in the type of occupations required in individual industries, however, have an even more profound effect on the number of jobs created in each *occupation* (see figure 1-24).

All the scenarios share some characteristics. Employment in manufacturing during the next two dec-

Figure 1-24.-Why Occupation Shares May Change



How To Read This Figure: The "Trend" scenario examined in chapter 13 estimates that between 1984 and the year 2005, the share of all jobs held by people classified as "other professionals" will increase 1.3 percentage points. These occupations would have increased their share 0.9 percentage points if only staffing patterns *within* businesses had changed (the scenario assumes sales workers in proportion to other workers in most businesses). All else being equal, the comparatively slow rate of growth expected in the productivity assumed for businesses using large numbers of "other professionals" would result in a 0.4 percentage point increase in the share of these occupations.

SOURCE: Office of Technology Assessment (see table 13-8 of ch. 13).

ades will not decline as rapidly as it has in the past 20 years. Manufacturing employment seems likely to fall from about 20 percent of all jobs to between 16 and 18 percent in 2005. Measured as a (constant dollar) percentage of GNP, manufacturing may fall by only 1 to 2 percentage points, with declines occurring primarily in manufacturing sectors that now pay comparatively high wages. Also breaking a trend, jobs in transactional activities (such as banking, insurance, law, and business services) seem unlikely to grow substantially as a fraction of all jobs. This results in part from the fact that productivity may grow sharply in "paper pushing" activities, thereby reducing the work force required.

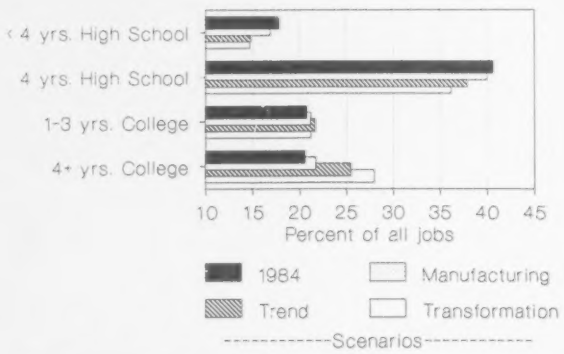
The characteristics of employment possible in the future differ most strikingly when measured by the type of job created. An economy that manages to build growth primarily around a revitalization of traditional manufacturing produces many more craft workers, precision production operators, and other "hands-on" manufacturing occupations. An economy moving sharply to new production networks generates many fewer jobs of this type, twice as many jobs for technical professionals (compared with an economy following 1984 staffing patterns), nearly 25 percent more managers and management support personnel, and 30 to 40 percent more sales workers. There would also be a 30 percent decline in jobs involving routine data entry and manipulation, and fewer jobs for the most low-paid occupations (food preparation, low-paid service workers, laborers, and farm labor).

The transformation scenarios have the effect of reducing employment in categories that traditionally pay low wages (the fraction of all workers now in occupations paying less than two-thirds of median wages could fall by 40 percent) while increasing employment in traditionally well-paid jobs (the fraction of all workers in occupations now paying more than 33 percent above the median wage could grow 50 to 60 percent). Of course, nearly all these occupations would be redefined if such a transformation took place. Many managers are likely to have more routine jobs than today's managers. Sales workers in the future could have more demanding jobs if they were more tightly integrated into inventory control and production networks, and given greater control over the design and tailoring of products sold.

The statistics say little about the quality of the working environment, an employee's control over working life, or satisfaction with what is accomplished. It does appear, however, that a restructured economy could generate large numbers of interesting and rewarding jobs, ranging from interesting "face-to-face" sales positions, to technicians installing and repairing a continuing series of new hardware and software, to managers wrestling to build new teams for specialized projects. These jobs will be in occupations that currently require a high level of education. The educational attainment level experiencing the fastest increase in its share of jobs, both currently and under the Transformation and Trend scenarios, is the highest—four or more years of college (see figure 1-25).

On the other hand, it is also possible to produce jobs that allow individual employees few initiatives and monitor performance with Orwellean precision using advanced communication networks. The combination of technology and large numbers of entry-level people with poor basic education could force (or tempt) employers to produce large numbers of jobs requiring minimal training for people considered interchangeable and disposable.

Figure 1-25.-Educational Requirements of Future Scenarios



How To Read This Figure: College graduates held about 21% of all jobs in 1984 but would hold nearly 28% of all jobs under the assumptions of the Transformation scenarios.

SOURCE: Office of Technology Assessment (see figure 13-2 of ch. 13).

A Concluding Note

The calculations just presented, coupled with the more qualitative descriptions that preceded them, describe starkly contrasting futures for the U.S. economy. They paint very different pictures of the future of critical amenities, the potential for growth in major types of businesses, the relative position of the United States in the world economy, and the nature and rewards of jobs available. The range of possibilities is shown not as forecasts but as possibilities—possibilities that illustrate the power of and the need for careful choice in the construction of public policy.

U.S. GOVERNMENT PRINTING OFFICE : 1988 O - 52-636 : QL 3

Superintendent of Documents Publication Order Form

Order Processing Code
*6355

Charge your order. It's easy!

☐ **YES,** please send me the following indicated publications:

Technology and the American Economic Transition: Choices for the Future.
GPO stock number 052-003-01096-8; price $20.00.

1. The total cost of my order is $_____ (International customers please add an additional 25%.) All prices include regular domestic postage and handling and are good through 10/88. After this date, please call Order and Information Desk at 202-783-3238 to verify prices.

Please Type or Print

2. _____
(Company or personal name)

_____
(Additional address/attention line)

_____
(Street address)

_____
(City, State, ZIP Code)

(_____) _____
(Daytime phone including area code)

3. Please choose method of payment:

☐ Check payable to the Superintendent of Documents
☐ GPO Deposit Account ☐☐☐☐☐☐☐-☐
☐ VISA, CHOICE or MasterCard Account
☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

_____ ***Thank you for your order!***
(Credit card expiration date)

_____
(Signature)

5/88

4. Mail To: Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325

CONGRESS OF THE UNITED STATES
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510-8025

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
OFFICE OF TECHNOLOGY ASSESSMENT
379

OTA-TET-284

MAY 1988